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and the
1995 ANNUAL IMPORTED FIRE ANT CONFERENCE

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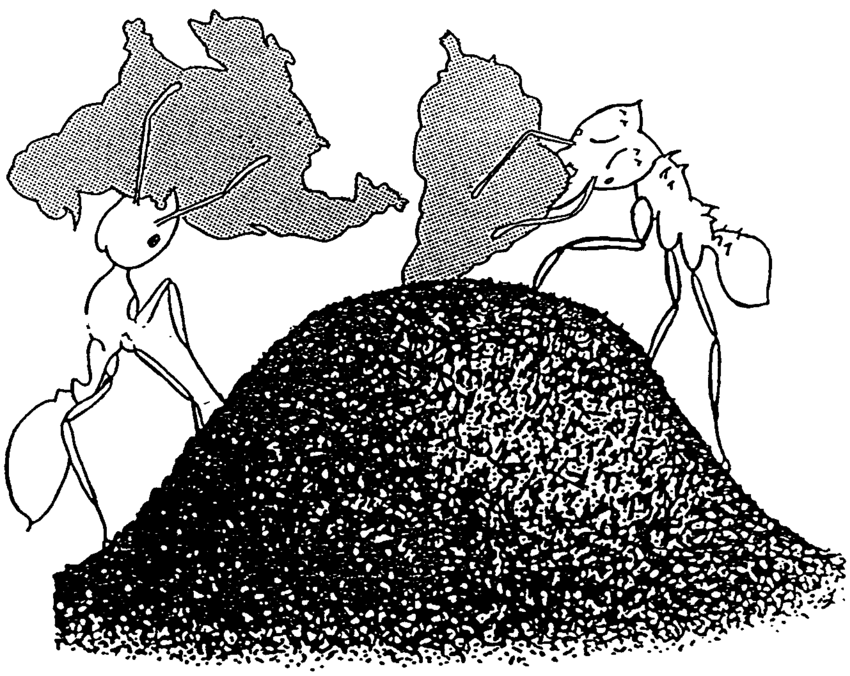

ECOLOGICAL DETERMINANTS OF PALO-VERDE TREE AND CREOSOTEBUSH TARGETING BY THE LEAFCUTTING ANT *ATTA MEXICANA* IN THE SONORAN DESERT OF ARIZONA

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The leafcutting ant *Atta mexicana* occurs in the USA only at Organ Pipe Cactus National Monument in southern Arizona. In this desert habitat, the large nests are found along arroyo channels, and they use an extensive system of lateral tunnels (5-130 m long) for foraging activity. Creosotebush (*Larrea tridentata*) and Palo-Verde Trees (*Cercidium microphyllum* and *C. floridum*) are the major dietary components for these colonies. Individual trees and shrubs of these species were mapped and tagged around two field colonies, and the patterns of individual plant use were studied over a 14-month period from November 1988 through December 1989. Data was collected at 10-day intervals during the period.

Creosotebush is an common evergreen shrub that is used heavily by *A. mexicana* from November through early April, and also in June and July. Plants nearest the tunnel openings are used most frequently, but because the numerous tunnel openings are widely scattered around the colony center, the targeted plants are widely dispersed in all directions around the center. Up to 100 creosotebush plants may be targeted simultaneously. The ants change targets frequently; as a result, no plants are killed by defoliation and few (<5%) lose more than 50% of their foliage. However, some individuals are attacked much more frequently than others and usage is nonrandom both within and between seasons; numerous trunk trails channel foragers from tunnels into local areas within the 1-4 ha foraging range.

Palo-verde Trees are winter and/or drought-deciduous. Heavy usage begins in April when new foliage and inflorescences are produced, and continues until local resources are depleted in early Summer. Nearby trees are targeted first and usage continues until all leaves and flowers are cut or collected under the tree; more distant trees are targeted after nearby resources are depleted. Thus, attack frequency (duration of use) is determined by tree size (larger trees requiring more time to defoliate) and by tree distance from the nearest tunnel opening; nearly all individuals within 80 m of the colony center are visited at some point. Only a few small specimens escape attack. Summer rainfall triggers new leaf production and the ants retarget the nearest palo-verde trees, moving outward again as nearby targets are defoliated. From April through early November, only 4-8 trunk trails are used to reach Palo-verde tree targets.

Although *Atta mexicana* foraging patterns in the Sonoran Desert do not exhibit primary adaptation for "conservational" foraging that minimizes long-term impact on their food resources, some aspects (e.g. highly dispersed creosote targeting) fit within this strategy.

RECRUITMENT PATTERNS IN FORAGING LEAF-CUTTING ANTS (FORMICIDAE; ATTINI); IMPLICATIONS FOR BAITING STRATEGIES

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Leaf-cutting ants cause significant damage to agricultural crops, pastures and tree plantations through their activities as leaf harvesters (Cherrett 1986, Jaffe 1986, Vilela 1986). Recently several chemical formulations have been identified to control the Texas leaf-cutting ant, *Atta texana* (Buckley) (Cameron 1990). The development of effective baiting strategies must also consider the physical properties of baits, because *Atta* has polymorphic foragers that respond to the physical characteristics of their forage plants (Parkar 1925, Lutz 1929, Fowler and Robinson 1979, Rudolph & Loudon 1986, Nichols-Orians & Schultz 1989, Waller 1989). Information on the natural foraging patterns of leaf-cutters can be used to design the most appropriate bait size and to direct the timing and location of bait placement. Factors that are likely to influence the efficiency of bait retrieval include particle size, distance from the nest entrance and amount of bait offered. In the present study I examined how these factors affected foraging on baits by *Atta texana*.

Materials and Methods

Experiments were performed at the Brackenridge Field Laboratory of the University of Texas in Austin, Texas. Ants foraging from nest entrances opening from the central mound or from subterranean tunnels (Waller 1986) were used in the following experiments:

Particle size

In these experiments, leaf discs were punched or cut from *Smilax bonanox* leaves and placed along active foraging trails within a meter from the nest entrance. Discs were either "small" (6 mm diam discs) or "large" (1 cm x 1 cm square discs). For each sample, approximately 30 ants retrieving these discs were collected as they returned to the nest entrance and measured for headwidth using a dissecting microscope with an ocular micrometer. Foraging rate was determined by counting the number of laden ants per minute that crossed a point near the nest entrance. Collections were made on pairs of trails emanating from the same entrance where ants foraged on either cracked or whole corn kernel baits. Five pairs of collections were made for small disc experiments, and two pairs of collections were made for large disc experiments. The effects of disc size and corn size on disc-carrier headwidth were analyzed using a two-factor analysis of variance. On one date one sample of control ants without burdens was collected from each of the cracked corn and whole corn trails, and differences in their headwidths were analyzed with a Student's t-test.

Distance

In these experiments, approximately 30 ants per sample were collected at two distances along a trail, at 1 m and 15 m from the nest entrance. Pairs of collections were made on three separate dates at each distance for ant foragers carrying *Lonicera japonica* leaves in January and February. Data were analyzed using analysis of variance that examined the effect of distance on ant headwidth, blocked by collection date.

Amount

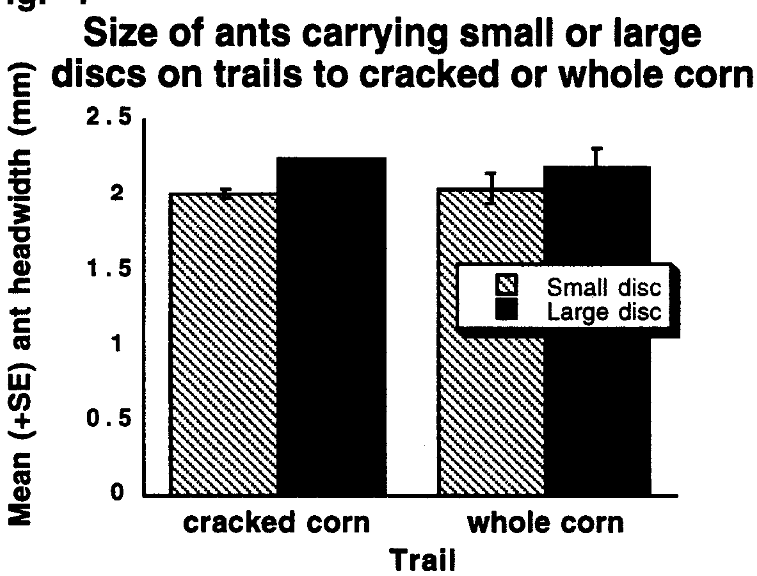
In these experiments baits containing either "low" or "high" amounts of forage substrate were placed approximately 1 m from the nest entrance. For each sample, approximately 30 unladen outgoing ants recruiting to baits were collected and measured for ant headwidth. Foraging rate was measured as the number of ants approaching the bait per minute. In corn experiments, baits consisted of finely-cracked corn, with 10 cc for "low" amount baits and 90 cc for "high" amount baits. Two identical corn bait experiments ("Corn 1" and "Corn 2" were performed). One leaf experiment was performed, with baits consisting of new Texas oak, *Quercus texana,* leaves. There were 10 leaves for the "low" amount bait and 80 leaves for the "high" amount bait. Analysis of variance was used to examine the effect of bait amount on ant headwidth for the corn experiments, blocked by test date, and a Student's t-test was used to analyze the results of the Texas oak leaf bait experiment.

Results

Particle size

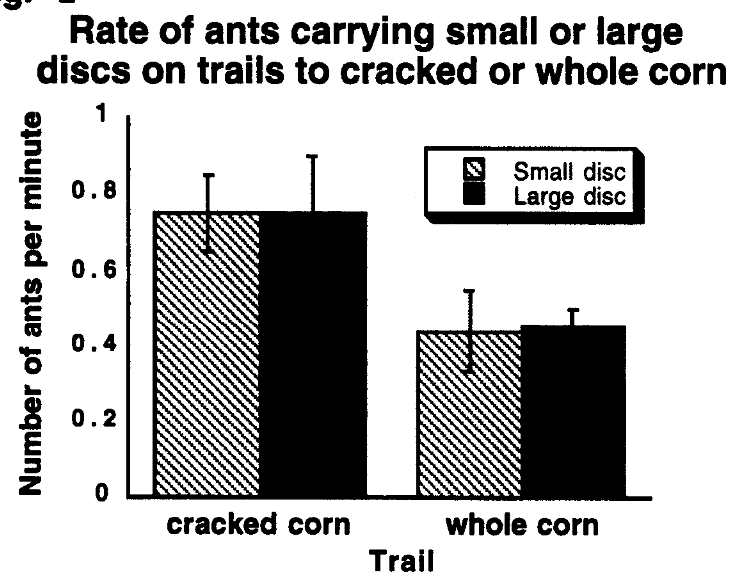
Ants carrying large discs had significantly greater headwidths than ants carrying small discs on trails to piles of both cracked corn and whole corn (ANOVA, F = 11.501, p = 0.0008) (fig. 1). There was no difference in size for disc-carrying ants on cracked corn or whole corn trails (fig. 1), however. Control foragers without burdens were signifcantly larger on whole corn trails than on cracked corn trails; mean ant headwidth of control ants was 2.28 mm + 0.56 SD (n = 29) on the whole corn trail and 1.79 mm + 0.20 SD (n = 21) on the cracked corn trail (Student's t-test, 2-tailed, t = -3.905, p = 0.0003).

Fig. 1



Foraging rates of ants carrying both small and large discs were faster for ants on trails to cracked corn than on trails to whole corn kernels (ANOVA, F = 5.191, p = 0.0437), but there was no difference in rate of ants carrying small versus big discs (Anova, F = .001, p = 0.9709) (fig. 2).

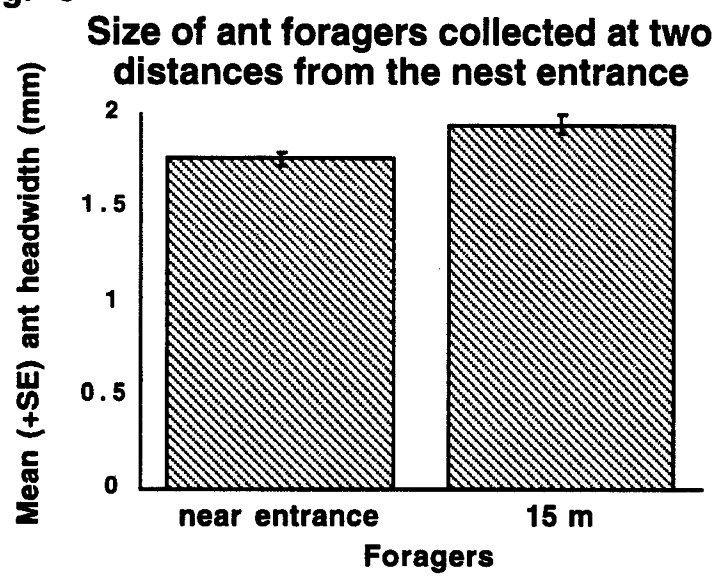
Fig. 2



Distance

Foragers collected at 15 m from the nest entrance were significantly larger than ants collected near the entrance (ANOVA, F = 7.352, p = 0.0074) (fig. 3).

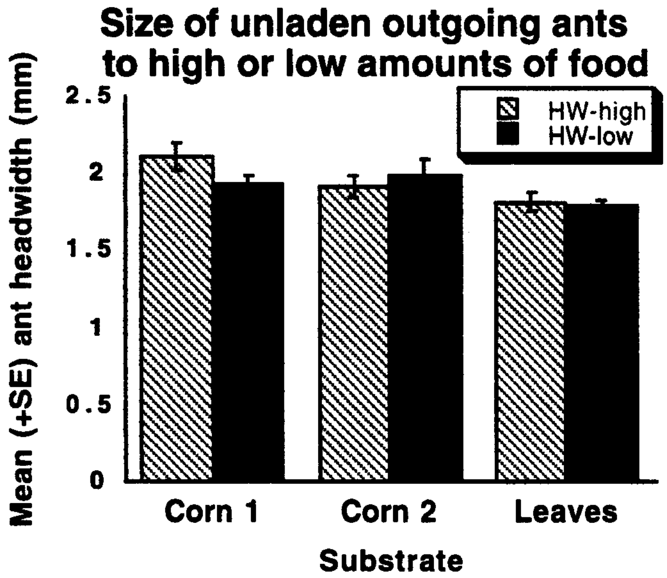
Fig. 3



Amount

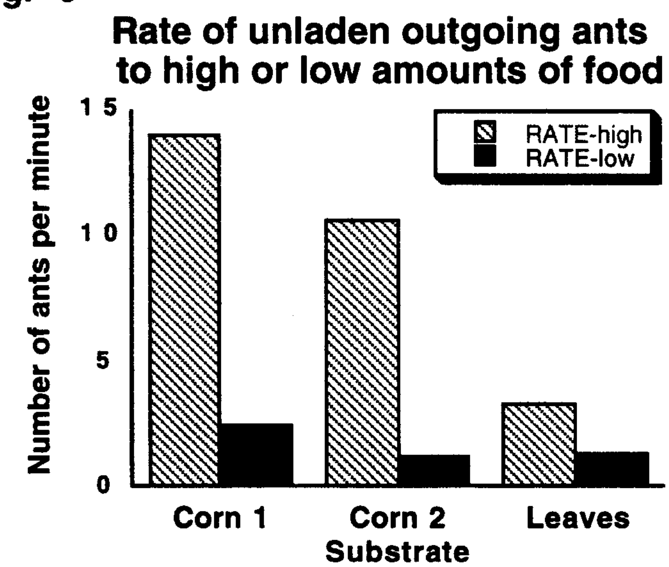
Unladen outgoing ants recruiting to high amounts of bait did not differ in headwidth from ants recruiting to low amounts of bait for either cracked corn baits (ANOVA, $F = 0.541$, $df = 1$, $p = 0.4635$) or Texas oak leaf piles (Student's $t = 0.3433$, $df = 56$, not significant) (fig. 4).

Fig. 4



Ants recruited to high amounts of bait at greater rates than to low amounts of bait in both corn and leaf experiments (fig. 5).

Fig. 5



Discussion

Particle size, distance from the nest and bait amount all influenced recruitment to food sources by *Atta texana* in these experiments. Ants retrieving small leaf discs were significantly smaller than ants retrieving large leaf discs on trails to both cracked corn and whole corn kernel baits. Control ants without burdens on cracked corn trails were significantly smaller than ants without burdens on whole corn kernel trails, but disc-carrying ants on these trails did not differ in size, indicating that ants matched their own sizes to burden sizes. Previous studies have demonstrated that *Atta texana* recruits smaller foragers to soft leaves or small particle baits (cracked corn), and larger foragers to hard leaves or large particle baits (whole corn kernels) (Waller 1989), and leaf-cutters frequently match ant size to burden size (Wilson 1980, Wetterer 1990). In the present study, disc size did not affect the foraging rate of disc retrievers, but ants foraged faster on trails to cracked corn than on trails to whole corn kernels. These data suggest that cracked corn baits would result in quick, efficient bait retrieval.

Distance from the nest entrance influenced forager size in this study, with larger ants collected at 15 m from the nest and smaller ants collected near the nest entrance. leafcutters frequently forage along trunk trails at great distances from the nest (Shepherd 1982). In a laboratory study, Roces (1990) found that leaf-cutters cut larger discs per ant size at greater distances from the nest. Foragers may increase foraging efficiency by collecting bigger burdens at greater distances to compensate for the greater energy expenditure of long-distance foraging (Wetterer 1989). These results suggest that larger bait particles placed at greater distances from the nest might be more readily retrieved than small bait particles. Further work is required to determine optimum bait size at specific distances from the nest. Most likely the best location for baits is directly next to nest entrances.

The amount of bait offered did not affect the size of *Atta texana* foragers recruited to baits for either corn baits with discrete particle sizes or for leaf baits which must be cut. However, ants recruited more quickly to large amounts of baits. These results suggest that the common practice of broadcasting bait pellets in an infested area might be less effective than placing concentrated amounts of bait near identified nests. Concentrated baits are likely to be retrieved more quickly than scattered baits, with fewer bait particles "missed" by searching foragers.

Acknowledgments

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Literature Cited

Cameron, R.S. 1990. Potential baits for control of the Texas leaf-cutting ant, *Atta texana* (Hymenoptera: Formicidae). Applied Myrmecology (Vander Meer, Jaffe & Ceneo, eds.) Westview Press, Boulder. pp. 628-637.

Cherrett, J.M. 1986. History of the leaf-cutting ant problem. Fire Ants and Leaf-cutting Ants (Lofgren, Vander Meer, eds.) Westview Press, Boulder. pp. 10-17.

Fowler, H.G. & S.W. Robinson. 1979. Foraging by *Atta sexdens* (Formicidae: Attini): seasonal patterns, caste and efficiency. Ecol. Entomol. 4: 239-247.

Jaffe, K. 1986. Control of *Atta* and *Acromyrmex* spp. in pine tree plantations in the Venezuelan Llanos. Fire Ants and Leaf-cutting Ants (Lofgren, Vander Meer, eds.) Westview Press, Boulder. pp. 409-416.

Lutz, F.E. 1929. Observations on leaf-cutting ants. Amer. Mus. Novitates 388: 1-21.

Nichols-Orians, C.M. & J.C. Schultz. 1989. Leaf toughness affects leaf harvesting by the leaf-cutter ant, *Atta cephalotes* (L.) (Hymenoptera: Formicidae). Biotropica 21: 80-83.

Parkar, G.H. 1925. The weight of vegetation transported by tropical fungus ants. Psyche 32: 227-228.

Roces, F. 1990. Leaf-cutting ants cut fragment sizes in relation to the distance from the nest. Anim. Behav. 40: 1181-1183.

Rudolph, S.G. & K. Loudon. 1986. Load size selection by foraging leaf-cutter ants (*Atta cephalotes*). Ecol. Entomol. 11: 401-410.

Shepherd, J.D. 1982. Trunk trails and the searching strategy of a leaf-cutter ant, *Atta colombica*. Behav. Ecol. Sociobiol. 11: 77-84.

Vilela, E.F. 1986. Status of leaf-cutting ant control in forest plantations in Brazil. Fire Ants and Leaf-cutting Ants (Lofgren, Vander Meer, eds.) Westview Press, Boulder. pp. 399-408.

Waller, D.A. 1986. The foraging ecology of *Atta texana* in Texas. Fire Ants and Leaf-cutting Ants (Lofgren, Vander Meer, eds.) Westview Press, Boulder. pp. 146-158.

Waller, D.A. 1989. Size-related foraging in the leaf-cutting ant *Atta texana* (Buckley) (Formicidae: Attini). Functional Ecology 3: 461-468.

Wetterer, J.K. 1989. Central place foraging theory: When load size affects travel time. Theor. Population Biol. 36: 267-280.

Wetterer, J.K. 1990. Diel changes in forager size, activity, and load selectivity in a tropical leaf-cutting ant, *Atta cephalotes*. Ecol. Entomol.15: 97-104.

Wilson, E.O. 1980. Caste and division of labor in leaf-cutter ants. I. The overall pattern in *A. sexdens*. Behav. Ecol. Sociobiol. 7: 143-156.

Distribution and categorization of *Camponotus* spp. north of Mexico as nuisance or structurally damaging pests.

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Introduction

Camponotus is the largest genus of ants with probably a thousand valid species (Brown 1973). These ants are among the most widespread of all the ants and occur from Chile to the Arctic Circle, from New Zealand to Polynesia and Africa. This distribution includes all zoographical regions from moist forested areas to more open, xeric areas such as grassland and even semidesert. *Camponotus* currently consists of ants in 54 subgenera worldwide (Brown 1973). Seven subgenera of *Camponotus* are represented in North America. However, this paper will concentrate on the role of carpenter ants as structural or nuisance pests, and only members in the subgenera *Camponotus, Myrmentoma, Tanaemyrmex*, *Myrmobrachys,* and *Myrmothrix* are included.

Categorization of ants in the five subgenera as structural or nuisance pests

Subgenus *Camponotus*: The ants in this subgenus have somewhat disparate habits, but most nest in wood, thus the common name carpenter ants. The species that cause the greatest damage to structures belong to this group.

Structural Pests	Nuisance Pests
C. herculeanus (L.)	*C. americanus* Mayr
C. modoc Wheeler	*C. ferrugineus* (F.)
C. novaeboracensis (Fitch)	*C. laevigatus* (Smith)
C. pennsylvanicus (DeGeer)	

Subgenus *Myrmentoma* (Snelling 1988): Most species of *Myrmentoma* nest in preformed cavities in woody tissues as in trees, stems of shrubs, or in pithy stalks. However, *C. essigi* , *C. nearcticus*, and *C. clarithorax* will excavate sound wood. The worker ants are small and are not readily recognized as *Camponotus* by most observers (Hansen and Akre 1994). The nests are smaller than nests of ants in the subgenus Camponotus. Because of the small size of the nests of this subgenera, these are all categorized as nuisance pests.

C. clarithorax Emery	*C. caryae* (Fitch)
C. essigi (M. R. Smith)	*C. decipiens* Emery
C. nearcticus Emery	*C. discolor* (Buckley)
C. hyatti Emery	*C. sayi* Emery

Subgenus *Tanaemyrmex* (Snelling 1970): Most species of *Tanaemyrmex* nest in dry, gravely soil or in wood that is usually buried under this type of soil. Species associated with structural infestations often nest in wood that has been damaged by water.

Structural Pests	Nuisance Pests
C. acutirostris Wheeler	*C. castaneus* (Latreille)
C. variegatus (Fr. Smith)	*C. semitestaceus* Emery
C. vicinus Mayr	*C. tortuganus* Emery

Subgenus *Myrmothrix:* *C. abdominalis floridanus* (Buckley) is an aggressive ant that nests in logs and stumps. It is a pest of honey bee colonies and is also a serious structural pest.

Subgenus *Myrmobrachys:* These ants nest under bark, in hollow branches of trees and shrubs, and in logs and stumps. Colonies are small and hard to find. Only one species, *C. planatus* Roger, in this subgenus has been associated with structures. This ant is generally considered to be a nuisance pest.

Nesting habits and distribution of species that are structural and nuisance pests

Subgenus *Camponotus*

C. americanus Mayr ranges over much of eastern United States and although it is usually considered a ground nesting species, it has been recorded in structures in Tennessee and Louisiana.

C. ferrugineus (F.), the Rust Colored Carpenter Ant, is found in the eastern United States. These ants nest in well-rotted wood and galleries may extend into soil. Although this species has been recorded in structures, it is not a major pest.

C. herculeanus (L.) is found in both the eastern and western United States. It is rare in North Dakota or in any nonforested area (Wheeler and Wheeler 1963). However, it is the second most common structural and pest ant species in Minnesota with colonies of 3,000->12,000 workers. This species nearly exclusively nests in wood such as standing trees or stumps. It is found in the same forested areas as *C. modoc.* and *C. pennsylvanicus.* This species is apparently a structural problem in all eastern states and provinces. However, it is not listed in the New York carpenter ant bulletin (Simeone et al. 1988). Although large colonies of this species also occur in the Pacific Northwest, it is not commonly recorded as a pest.

C. laevigatus (Smith) was reported as commonly found in houses in the Pacific Northwest (Furniss and Carolin 1977); however, this is not true. It is a wood nesting species that is rarely found in houses. It is most commonly found around structures in wood used in landscaping such as pieces of driftwood or railroad ties. Cook (1953) reported that *C. laevigatus* has been found tunneling in moist, rotting timbers in houses. This ant occurs throughout the west.

C. modoc Wheeler colonies are large, with up to 50,000 total workers present in the parent and several (usually) satellite colonies. Main nests are commonly found outside the structure in an area where there is permanent moisture such as the heartwood of living trees, old stumps, or wood used in landscaping. Nests within the structure are usually satellite nests and may be found in structural timbers, under insulation, or in void areas. This is exclusively a wood inhabiting species, and it is the principal structural pest in the northwestern United States and in southwestern Canada. It also excavates fiberglass or foam insulation for nests, and is frequently a nuisance due to the noise the workers produce as they chew wood and other materials for excavation.

C. novaeboracensis (Fitch), the Red Carpenter Ant, is found throughout the northern United States and southern Canada but has been observed more commonly east of the Dakotas. Colonies of *C. novaeboracensis* are extremely common in Minnesota and it is the most common carpenter ant in North Dakota (Wheeler and Wheeler 1963). It is also extremely common in eastern states and provinces. Colonies usually nest in standing or downed trees, but nests also occur under rocks and in cow dung (Wheeler and Wheeler 1963). In northern Minnesota colonies occur in nearly all logged areas in the stumps, and in standing dead or downed trembling aspen and other species of *Populus* L.. Colonies are both a nuisance and a structural pest in houses in the East. However, colonies are usually small (ca 3,000 workers), and structural damage is usually slight before control is effected. In the Pacific Northwest this species is not common as a pest in houses; however occasionally it is reported.

C. pennsylvanicus (DeGeer), the Black Carpenter Ant, nests exclusively in wood (Drooz 1985), and it is the principal structural pest of eastern North America. The biology and economic importance of this species parallels that of *C. modoc* found in western North America where main nests are usually found outside the structure, and satellite nests are found within the structure in voids, under insulation, and in structural timbers. Colonies of *C. pennsylvanicus* are apparently smaller than those of *C. modoc*, but workers in colonies probably number 10-15,000, a figure much larger than previously reported (Akre et al. 1994).

Subgenus *Myrmentoma*

C. caryae (Fitch) ranges from New York west to Iowa and south to Florida. Snelling (1988) separates this species from *C. discolor* but indicates that the two may not be separate species. Although this ant nests within structures, they are found only in hollow areas such as voids. A colony consists of only a few hundred workers.

C. clarithorax Emery occurs only in California and southern Oregon where it has been commonly collected in structures. Nests occur in hollow areas within buildings.

C. decipiens Emery occurs from Georgia and northern Florida west to Texas and north to North Dakota. Smith (1965) used the synonym, *C. rasilis*, in describing this species as a nuisance in structures where they nest in hollow areas. The colonies consist of a few hundred individuals.

C. discolor (Buckley) occurs in areas further west than *C. caryae* and extends from Texas east to South Carolina and north to North Dakota. It nests in dead or living trees. Snelling (1988) indicated that this may not be a separate species. However, this species has been included because of earlier reports of *C. caryae* occurring in structures and the confusion between the two species.

C. essigi (M. R. Smith) ranges from Mexico to Southern Canada and has been commonly observed nesting in hollow areas within structures. However, little structural damage occurs. Size of a colony may number up to several hundred individuals. These ants are most commonly observed within structures in early spring as they leave to nest and forage in trees.

C. hyatti Emery ranges from southern California to southern Oregon east to Arizona and to Idaho. Nests are established in wood. Ebeling (1975) noted this species as a nuisance pest in structures.

C. nearcticus Emery has the widest range of all the *Myrmentoma* occurring throughout southern Canada and the United States. Colonies are usually found in dead twigs and branches, or under the bark of dead or living trees, in the hollow stems of plants, inside insect galls, and in the wood of houses, especially in roofing (Drooz 1985). It has been observed in structures as a nuisance pest nesting in hollow areas. Colonies seem to be small, ca 300 workers.

C. sayi Emery occurs in southern United States and Mexico extending from southern California, north to Nevada and Utah, and east to Texas. These ants are chiefly nuisance pests feeding on sweets within structures.

Subgenus *Tanaemyrmex*

C. acutirostris Wheeler range is limited to western Texas, New Mexico, and Arizona. Large colonies have been reported to occur in structures in Arizona. This ant nests underground in buried wood and where it occurs in newer structures, the infestation is probably due to the incomplete excavation of woody materials at the building site.

C. castaneus (Latreille) nests are found in rotten stumps or logs in the soil (Drooz 1985). *C. castaneus* is also frequently found in houses but is not considered to be of major importance. This species usually nests outside and will frequent structures for food after dusk when these ants are most active. The range of this species is from Iowa to New York and south to Texas and Florida (Smith 1965).

C. semitestaceus Emery are seldom observed because they are nocturnal foragers, and because the nests are usually under rocks in semidesert areas. Entrances to nests are also cryptic. A study of colonies in the Columbia Basin of Washington showed most (75%) nest entrances were associated with the stems of sagebrush (Gano and Rogers 1983). This species occurs in California, Oregon, and Washington in arid regions. Size of an individual colony is small. This ant is infrequent in structures and has not been observed nesting there. Occasionally these ants may forage into the house or more frequently winged queens may wander inside a structure after a mating swarm in the spring.

C. tortuganus Emery has a narrow range in southern Florida. Smith (1965) and Drooz (1985) cite this ant as a frequent house pest. Small colonies of this ant nest in rotting wood or under rocks in the soil. Ants are also reported to nest in sidings, rafters, and porch roofs.

C. variegatus (Fr. Smith), the Hawaiian Carpenter Ant was undoubtedly introduced into Hawaii from SE Asia (Wilson and Taylor 1967), and is a serious nuisance pests in houses on all the Hawaiian Islands (Huddleston and Fluker 1968, Yates 1988). It has been collected on the coast of Washington and unconfirmed reports also place this ant in other coastal areas of Oregon and Washington . It is believed to have come in with wood crating around equipment. Nests are established in wood that has previously been hollowed out by termites, inside rotting logs and tree stumps, and in hollow areas in structures such as wall voids or doors. These ants have not been observed to excavate solid wood. However, the ants smear linen and furniture with a waxy material used to rear the brood when it nests in linen closets, trunks, and other household storage areas.

C. vicinus Mayr ranges from Mexico to southern Canada, inland to the Rocky Mountains, and extending east to the Dakotas and Alberta. These ants nest in a variety of habitats. They have been observed nesting under rocks in wooded areas, in rotting stumps and dead trees, in the heartwood of living trees, and in structures. *C. vicinus* is an important structural pest, second only to *C. modoc* in Washington State (Hansen and Akre 1985). These ants will mine solid wood but are more attracted to wood that has been damaged.

Subgenus *Myrmothrix*

C. abdominalis floridanus (Buckley), the Florida Carpenter Ant, ranges chiefly from Florida north to North Carolina and west to Mississippi. These ants have moderate to large colonies, and they are very adaptable with regard to nesting sites. Colonies are found in ground beneath objects, in dead branches of trees, in rotting logs and stumps, in woodwork of porches, roofs, kitchen sinks, and paneling. *C. abdominalis* is one of the more important house infesting ants in Florida and other parts of the south. It is a serious structural pest, a nuisance household pest, and a very serious pest of bee hives that they raid for food and sometimes usurp for living space. Although this ant does not have a dormant phase as do northern species, the remainder of the life cycle is similar. This is the only pestiferous species in the Subgenus *Myrmothrix*.

Subgenus *Myrmobrachys*

C. planatus Roger occurs in southern Florida, West Indies, southern Texas, and from Mexico to Colombia. These ants have been reported occurring in structures in a survey of pest control operators in Florida (Klotz, unpublished). The ant is arboreal and constructs its nests in decayed branches, hollow twigs, under bark, and in the bases of bromeliads (Creighton 1950). The colonies are small but individual ants are conspicuous because of their diurnal foraging activities.

References

Akre, R.D., L.D. Hansen, and E.A. Myhre. 1994. Colony size and polygyny in carpenter ants (Hymenoptera: Formicidae). J. Kan. Entomol. Soc. 67:1-9

Brown, W.D. 1973. A comparison of the Hylean and Congo-West African rain forest ant faunas, and Appendix: generic and subgeneric names proposed in the Family Formicidae, pp. 161-185. *In* B.J.Meggers, E.S. Ayensu, and W.D.Duckworth, eds. Tropical Forest Ecosystems in Africa and South America: A Comparative Review, Smithsonian Inst: Washington, D.C. 350p.

Cook, T.W. 1953. The Ants of California. Pacific: Palo Alto, CA 462 p.

Creighton, W.S. 1950. The Ants of North America. Bull. Mus. Comp. Zool. Harvard, Cambridge, MA 585 p.

Drooz, A.T., ed. 1985. Insects of Eastern Forests, USDA-FS. Misc. Publ. 1426. 608 p.

Ebeling, W. 1975. Urban Entomology. Univ. Calif., Div. Agric. Sci: Los Angeles, CA 695 p.

Furniss, R., and V. M. Carolin. 1977. Western Forest Insects. USDA-FS Misc. Publ. 1339. 654 p.

Gano, K.A., and L.E. Rogers. 1983. Colony density and activity times of the ant *Camponotus semitestaceus* (Hymenoptera: Formicidae) in the shrub steppe community. Ann. Entomol. Soc. Amer. 76: 958-963.

Hansen, L.D., and R.D. Akre. 1985. Biology of carpenter ants in Washington State (Hymenoptera: Formicidae: *Camponotus*). Melanderia 43:1-62.

Hansen, L.D., and R.D. Akre. 1994. Pest species of carpenter ants in North America. Proc. Natl. Conf. Urban Entomol. Feb. 20-22, 1994: 117.

Huddleston, E.W., and S.S. Fluker. 1968. Distribution of ant species in Hawaii. Proc. Hawaiian Entomol. Soc. 20: 45-69.

Simeone, J.B., L.P. Abrahamson, and C. Klass. 1988. Carpenter Ants. N.Y. State Tree Pest Leaflet No. F-3, State Univ: New York, Syracuse. 7 p.

Snelling, R. R. 1970. Studies on California ants, 5. Revisionary notes on some species of *Camponotus*, Subgenus *Tanaemyrmex* (Hymenoptera: Formicidae). Proc. Entomol. Soc. Wash. 72: 390-397.

Snelling, R.R. 1988. Taxonomic notes on Nearctic species of *Camponotus*, subgenus *Myrmentoma* (Hymenoptera: Formicidae). p. 55-78. *In* J.C.Trager, ed., Advances in Myrmecology. E.J.Brill, Leiden. 551 p.

Smith, M.R. 1965. House-infesting ants of the eastern United States: Their recognition, biology, and economic importance. ARS, USDA Tech. Bull. No. 1326. 105 p.

Wheeler, G.C., and J. Wheeler. 1963. The Ants of North Dakota. Univ. N. Dakota: Grand Forks, N. Dakota. 326 p.

Wilson, E.O., and R.W. Taylor. 1967. The ants of Polynesia (Hymenoptera: Formicidae). Pacific Insects Monograph 14. Entomology Department, Bernice P. Bishop Museum: Honolulu, Hawaii. 109 p.

Yates, J.R. 1988. Biology and control of the Hawaiian carpenter ant. Urban Pest Press: Univ. Hawaii, Coop. Ext. Vol. 1(2), 2 p.

RESPONSES OF *TAPINOMA MELANOCEPHALUM*, ARGENTINE ANTS, AND PHARAOH ANTS TO A BORIC ACID BAIT

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Summary

A 10% sugar-water solution containing 1% boric acid and a commercially available granular bait containing hydramethylnon (Maxforce Ant Killer Granular Bait) were exposed to small laboratory colonies of either *Tapinoma melanocephalum*; Argentine ants, *Linepithema humile*; or, Pharaoh ants, *Monomorium pharaonis*. Colonies ranged in size from 200 to 345 workers, 100 to 500 mm^2 of brood (0.2 grams for Pharaoh ants), and 2 to 10 queens depending on species. The bait solution (14 ml) was provided to colonies for 3 days or continuously for 8 weeks, and the granular bait (0.5 grams) was exposed continuously. Control colonies were exposed to a 10% sugar-water solution (14 ml) continuously. All colonies were starved for 1 day prior to bait exposure, and the normal diet of honey-water and crickets was provided 3 days after initial bait exposure. Six colonies were used for each type of bait exposure for *T. melanocephalum* and the Argentine ants; 4 colonies for the Pharaoh ants.

T. melanocephalum workers and brood were reduced over 90% by 3 weeks for both the 3 day and continuous boric acid solution exposure. The hydramethylnon bait did not reduce *T. melanocephalum* colonies. A 90% reduction in Argentine ant workers and brood was observed in the continuous boric acid solution at 3 weeks, while the 3 day boric acid exposure resulted in a 75 and 88% worker and brood reduction, respectively. For the hydramethylnon treatment, worker and brood reductions of 86% and 77% were observed after 3 weeks. By week 7, the continuous boric acid and the hydramethylnon baited colonies were reduced by greater than 90%. Pharaoh ant worker reduction was over 90% and brood reduction about 60% at 3 weeks for the continuous boric acid and hydramethylnon bait. By week 5, these colonies were virtually eliminated. The 3 day boric acid exposure resulted in a 60 to 50% reduction in workers and brood after 8 weeks. Control colonies for all ant species generally increased in population during the study. These results suggest the boric acid sugar-water solution may be an effective toxic bait for pest ants that prefer carbohydrate based attractants. However these results must be confirmed with large colonies under field conditions.

DEVELOPMENT OF A SUCCESSFUL CONTROL STRATEGY AGAINST THE ARGENTINE ANT BASED ON KEY ASPECTS OF THE PESTS'S LIFE HISTORY.

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Introduction

The Argentine ant, *Linepithema humile* (Mayr), is an exotic species which flourishes in disturbed habitats in many parts of the world (Passera 1994). In the United States, *L. humile* is well established in the Southern states and California, where it is a frequent source of homeowner complaints (Mallis 1982). The Argentine ant is only a minor component of the ant community in its native habitat and does not appear to displace other species (Majer 1994). However, tramp ant species, like *L. humile*, often derive this status after being released from natural constraints upon introduction to new habitats (Passera 1994).

The Argentine ant is omnivorous, and usually nests outdoors under stones, sidewalks, decayed wood, rubbish piles, foundations, and at the base of trees (Newell 1909). A generalist in both its nesting and feeding habits *L. humile* thrives best in warm, moist conditions (Majer 1994). In addition to its generalist nature, the Argentine ant lives in multiple queen, unicolonial groups which are capable of fission or aggregation. This high reproductive capacity combined with an aggressive mass recruitment resource utilization strategy allows this introduced species to out compete most native ant species (Deneubourg et al. 1990, Erickson 1971).

These conditions, disturbed habitat and moisture, are often found at new construction with irrigated landscapes. As a result, there are major infestations around apartment complexes in the Atlanta, Georgia area. This paper discusses a successful control strategy which was designed to take advantage of several aspects of the Argentine ants life history. These include the multiple queen status of these pests, its mass recruitment resource utilization strategy, and outdoor nesting habits.

Materials and Methods

An apartment complex in Duluth, Georgia with a history of Argentine ant complaints was chosen as the test site. This complex consisted of 33 buildings on 15.6 hectares with an irrigated landscape using shade trees and ornamental plantings mulched with pine straw. Two commercially available containerized ant baits were tested in three temporally separated trials. The baits were Pro-Control® (Micro-Gen Equipment Corp.; 0.5% sulfluramid) and Maxforce® (Chlorox Co.; 0.9% hydramethylnon). Baits were contained within plastic bait stations.

Ant populations were monitored using empty bases of unused bait stations filled with 1 to 2 ml of 50% honey water. Monitoring stations were placed approximately every 5 to 6 m around the building foundation or where ant trails were observed. Monitoring stations were placed at their respective locations between 1000 and 1100 EDT and the numbers of ants recorded between 1300 and 1400 EDT on each sampling date. At the time pretreatment counts were taken, representative ant samples were collected in 70% ethyl alcohol and returned to the laboratory for identification. Only buildings with Argentine ants at greater than 95% of the monitoring stations were used in these studies. In 1992, two trials were conducted with 10 buildings in each trial receiving one of the two aforementioned bait treatments. In 1993, nine buildings were included in an additional study.

Bait stations were placed at 3-m intervals around the foundation-ground interface for each treatment building. Bait stations were collected and replaced with new bait stations every 4-5 wk during the 1992 trials and once every 2 wk in the 1993 study. To assess bait acceptance, the collected bait stations were returned to the laboratory, dismantled, and the amount of bait remaining in each station recorded. The scoring system used was a visual estimate of the amount of bait remaining in each station by building and treatment. Each bait station was placed in one of three categories; all bait removed (0% bait remaining), partial bait removal (0 - 100% bait remaining), or no bait removed (100% bait remaining).

Each building receiving a containerized ant bait treatment was considered one replicate. The number of ants per monitoring station per building per week were square-root transformed and analyzed using analysis of variance. Protected least significant difference mean separation technique was used to determine treatment differences (SAS Institute 1985).

Results and Discussion

Bait acceptance was equal between the two baits tested within each year tests were conducted (Table 1). Because baits were exchanged at different time intervals between years one cannot compare tests between years. However, there were no significant statistical differences between the baits tested within years for percentage of bait stations which were completely empty following exposure to ant populations in the field.

Numbers of ants recorded after treatment with either bait in all trials was lower than pretreatment counts (Table 2). These results indicate that using containerized ant baits in a perimeter treatment strategy was successful in reducing Argentine ant foraging activity around treatment buildings regardless of bait-type and active ingredient tested. Efficacy of these treatments was verified by the average number of ant complaints reported to the apartment complex management during the 1993 trial (Table 3). Complaints were highest from the treatment buildings prior to baiting and lower than untreated buildings after baiting.

The use of containerized ant baits in a perimeter treatment strategy was successful because this strategy took advantage of three key aspects of the Argentine ants life history. First, baits were used because of the need to provide nestmates, especially reproductives, with a toxicant. Baiting takes advantage of the social organization of ant colonies to distribute the toxicant obviating the need to find the source colony. In addition, by targeting the nest-bound colony members not only were forager numbers reduced but the colonys ability to replace them also was effected. Second, placing baits on the exterior perimeter of buildings provided the outdoor nesting Argentines with a palatable food resource before they entered the structures. This could have aided in reducing ant foraging activity on the interior because acceptable food resources were located prior to entry. At the very least, ants were provided with a food resource they could located and exploit without interference or notice by residents. In addition, this technique does not require entry into each individual apartment which reduces the time needed by PCO's to service an account and reduces insecticide use indoors. Third, bait stations provided discrete resource points for Argentine ants to exploit using their mass recruitment strategy which allows them to locate and exclusively exploit those resources.

Literature Cited

Erickson, J.M. 1971. The displacement of native ant species by the introduced Argentine ant *Iridomyrmex humilis* (Mayr). Psyche 78:257-266.

Deneubourg, J.-L., S. Aron, S. Gross, and J.M. Pasteels. 1990. The self-organizing exploratory pattern of the Argentine Ant. J. Insect Behavior. 3:159-168.

Majer, J.D. 1994. *In* Exotic ants: biology, impact and control of introduced species. D.F. Williams (ed), Westview Press, Boulder, CO.

Mallis, A. 1982. Handbook of pest control, 6th ed. Franzak & Foster, Cleveland, OH.

Newell, W. 1909. Measures suggested against the Argentine ant as a household pest. J. Econ. Entomol. 2:324-332.

Passera, L. 1994. *In* Exotic ants: biology, impact and control of introduced species. D.F. Williams (ed), Westview Press, Boulder, CO.

SAS Institute Inc. 1985. SAS user's guide: statistics. SAS Institute, Cary, N.C.

Tables

Table 1. Bait station rating results from stations scored by treatment, amount of bait remaining, and year* from containerized ant bait trials at Duluth, Georgia.

Treatment	Percentage of Bait Remaining 0%	>0<100%	100%
		1992	
Sulfluramid	95%	2%	3%
Hydramethylnon	94%	3%	3%
		1993	
Sulfluramid	51%	40%	9%
Hydramethylnon	69%	26%	5%

* Baits were in exchanged on a monthly basis in 1992 and every 2 weeks in 1993.

Table 2. Mean pre- and post-treatment number of Argentine ants counted per monitoring station by treatment and trial from containerized ant bait trials in Duluth, GA, 1992-3.

Trt**	FIRST TRIAL Mean ± SEM	SECOND TRIAL Mean ± SEM	THIRD TRIAL Mean ± SEM
		Pre-treatment	
Con	5.17 ± 1.17 A*	4.94 ± 1.28 A	105 ± 19.8 A
Sulf	19.49 ± 6.21 B	24.57 ± 7.23 B	98 ± 21.9 A
Hydra	18.38 ± 5.89 B	26.05 ± 7.34 B	104 ± 18.4 A
		Post-treatment	
Con	23.09 ± 5.88 A	21.07 ± 2.16 A	100 ± 24.6 A
Sulf	11.45 ± 1.27 B	8.68 ± 0.75 B	13 ± 7.8 B
Hydra	3.68 ± 0.39 C	4.91 ± 0.82 B	14 ± 14.0 B

* Means followed by the same letter within a column for each trial are not significantly different (LSD; P = 0.05).

** Treatment abrieviations are Con = Controls; Sulf = Sulfluramid; Hydra = Hydramethylnon

Table 3. Average number of ant complaints per week per building during 1993 containerized ant bait trial in Duluth, GA.

Month	Treated areas	Untreated areas
AUGUST (before treatment)	2.23	1.44
SEPTEMBER (during treatment)	1.33	1.42
OCTOBER-NOVEMBER (during + after treatment)	0.50	1.45

Source of alate alarm pheromones in *Solenopsis invicta*

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Mating flights of the red imported fire ant, *Solenopsis invicta*, typically occur one to two days after a rain, when soil temperatures are between 24 and 32 °C and surface winds are low (Rhoades and Davis 1967, Morrill 1974, Milio et al. 1988). Prior to flight, workers open special exit holes in the mound and winged alates emerge from the nest (Markin et al. 1971). At this time, workers swarm excitedly over the mound and exhibit many characteristics of alarm behavior, including frenzied running, rapid back and forth movement, and increased aggression (Markin et al. 1971, Obin and Vander Meer 1994). The purpose of this heightened worker activity may be to protect and aid alates in their flight, or to ready workers for attacks against newly mated queens attempting to initiate colonies near their mounds (Fowler 1982).

Obin and Vander Meer (1994) induced *S. invicta* mating flights in the laboratory and showed that chemical cues from both male and female alates, but not workers, attracted workers, induced alarm-recruitment behaviors in the workers, and promoted alate retrieval by workers. They proposed that volatile substances produced by the alates were responsible for eliciting the worker reactions. We investigated the glandular source of these alate-produced pheromones, focussing first on female alates flying during the winter months.

S. invicta workers were exposed to odors from 1) female alates collected during induced mating flights in the laboratory (flying alates), 2) female alates collected from field colonies (non-flying alates), 3) newly emerged female alates (less than 4 days old), 4) crushed body parts (head, thorax, abdomen) of female alates from each of the above categories, and 5) excised mandibular glands, post-pharyngeal glands, and poison sacs of flying female alates (1.6 queen equivalent per test).

Alarm reactions of workers were assessed in bioassays consisting of worker groups and brood from 17 monogyne *S. invicta* colonies set up in small petri dishes. All test odors (see above categories) were tested blind to the observer. Samples were prepared by drawing 3 ml of air with a syringe out of a vial containing the test odor. Air from the syringe (1 ml) was then slowly released directly over a worker group. Worker behavior was scored as either a reaction, in which at least one worker moved rapidly in response to the test odor, or as no reaction, when workers did not show any movement. In each test all 17 worker groups were subjected to several odors and an air control. The behavior of each worker group when exposed to a test odor was compared to their behavior when exposed to air using a modified G-test for repeated testing of the same individuals (McNemar tests for significance of changes). Data were pooled for five to nine replicates of each test (using different worker groups).

When disturbed by shaking the vials, all categories of female alates (flying, non-flying, and newly eclosed) caused a significant alarm reaction in the workers ($p<0.001$). Workers reacted much less strongly (although still significantly greater than air at $p<0.01$) to non-shaken (calm) flying alates, suggesting that the alates control release of the pheromone. Crushed heads of all categories of alates elicited a strong reaction in workers ($p<0.001$), while abdomens of flying and non-flying but not newly eclosed alates caused a reaction ($p<0.001$). Workers never responded to crushed thoraces. Excised mandibular glands and poison sacs crushed in mineral oil both elicited alarm reactions in the workers ($p<0.001$) while post-pharyngeal glands did not.

These results suggest that female alate mandibular glands and poison sacs may be the source of mating flight alarm pheromones in *S. invicta*. However, alarm behavior and attraction may be confounded in this bioassay. Tests for attraction using a Y-tube olfactometer revealed that poison sacs of flying and non-flying female alates attract workers (G-tests, $p<0.01$). This is not surprising since overwintering alates are known to be aberrant and may have begun to produce the queen attractant pheromone (found in the poison sac). Further studies using "normal" summer female alates and male alates (which have no poison sac or dufours gland) are planned in order to determine if the poison sac is indeed involved in mating flight activity.

The mandibular glands remain as the most likely source of the mating flight alarm pheromones since they are found in both male and female *S. invicta* alates and have been shown to be involved in mating flight attraction and alarm in other ant species (e.g. Brand et al. 1973, Fowler 1982). Workers of many ant species are known to release alarm pheromones from their mandibular glands (see Holldobler and Wilson 1990). We are currently working on identifying the chemical composition of the mandibular glands in order to pinpoint the alarm pheromone.

References Cited

Brand, J.M., R.M. Duffield, J.G. MacConnell, M.S. Blum, and H.M. Fales. 1973. Caste-specific compounds in male carpenter ants. Science. 179: 388-389.

Fowler, H.G. 1982. Male induction and function of workers' excitability during swarming in leaf-cutting ants (*Atta* and *Acromyrmex*) (Hymenoptera, Formicidae). International Journal of Invertebrate Reproduction. 4: 333-335.

Holldobler, B. and E.O. Wilson. 1990. The Ants. Harvard University Press, Cambridge, MA.

Markin, G.P., J.H. Dillier, S. O. Hill, M.S. Blum, and H.R. Hermann. 1971. Nuptial flight and flight ranges of the imported fire ant, *Solenopsis saevissima richteri* (Hymenoptera: Formicidae). Journal of the Georgia Entomological Society. 6: 145-156.

Milio, J., C. S. Lofgren, and D.F. Williams. 1988. Nuptial flight studies of field-collected colonies of *Solenopsis invicta* Buren. *In*: Trager, J.C. (ed.) Advances in Myrmecology. E.J. Brill, New York, NY.

Morrill, W.L. 1974. Production and flight of alate red imported fire ants. Environmental Entomology. 3: 265-271.

Obin, M.S. and R.K. Vander Meer. 1994. Alate semiochemicals release worker behavior during fire ant nuptial flights. Journal of Entomological Science. 29: 143-151.

Rhoades, W.C. and D.R. Davis. 1967. Effects of meteorological factors on the biology and control of the imported fire ant. Journal of Economic Entomology. 60: 554-558.

INTERACTION OF *SOLENOPSIS INVICTA* BUREN AND *PHEIDOLE DENTATA* MAYR ON PARASITIZED AND NON-PARASITIZED COCKROACH OOTHECAE

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Information on the predation impact of the red imported fire ant, *Solenopsis invicta* Buren, and the big-headed ant, *Pheidole dentata* Mayr, on parasitized and non-parasitized cockroach egg cases is anecdotal. S. *invicta* and several other ant species have been well documented as important biological control agents of insect pests, but little is understood of their influence on beneficials (Pimentel, 1955, Pimentel & Uhler 1969, Burnes & Melacon 1977, Summerlin et al. 1977, Sterling 1978, and Jamal & Hugh 1993). In Southeastern Louisiana, Wilson and Oliver (1969) identified foraging materials collected from S. *invicta* to include the Blattidae.

Van der Goot (1916) recognized the capacity of ants to disturb parasitoids in their search for hosts. Flanders (1951) and Way 1954) noted an apparent correlation between the rapidity of egg deposition by certain parasitoids and the incidence of their attack upon ant-attended hosts. In a series of laboratory tests, Bartlett (1961) noted that presence of the Argentine ant caused a 27.4 to 98.4% reduction in attack by some species of parasitoids upon *Coccus hesperidum*. In another study, Vinson and Scarborough (1991) observed that adult emergence of the parasitoid *Lysiphlebus testaceipes* Cresson from laboratory colonies of the corn aphid *Rhopalosiphum maidis* (Fitch), was reduced in the presence of the red imported fire ant.

This study provides an evaluation on the predation and interaction of *S. invicta* and *P. dentata* on nymphs and parasitoids emerging from P. *americana* oothecae, and whether the presence of S. *invicta* can affect the preemergence time of the parasitoid A. *hagenowii* from *P. americana* ootheca.

A. Predation and interaction of *Solenopsis invicta* Buren and *Pheidole dentata* Mayr on emerging nymphs of the cockroach *Periplaneta americana* Linnaeus

Materials and Methods

Twenty P. *americana* oothecae of known age were collected from laboratory reared colonies and maintained at 27-28°C, and 40-60% RH until within two days of anticipated eclosion. One ootheca was randomly selected and glued (suture upward) with Aleene's Tacky Glue® to the center of filter paper and placed in the center of a plastic box 34 x 26.6 x 8.5 cm. A video camera programmed for 24 hr recording time was positioned to focus on the ootheca and filter paper. An ant colony consisting of ca. 1,000 workers, a teaspoonful of brood, and queens (two for polygyne *S. invicta* and one for *P. dentata*) were placed adjacent to each plastic box. A two inch paper strip shaped to form an arch from the ant colony to the box served as a bridge for ants to forage across. Each day the ant colony was given one mealworm cut in half and a continuous supply of honey water (50:50, vol/vol) in a cotton-plugged test tube. Ant activity on the filter paper was recorded within a 3 x 2.3 cm area until cockroach emergence was completed and ant foraging activity returned to preemergence levels. The experiment was replicated five times.

Results and Discussion

Ant Capture of Cockroach Nymphs. Table 1 shows that the total numbers of roaches emerging from five *P. americana* oothecae in the presence of *S. invicta* and *P. dentata* ants were 74 and 71, respectively. An analysis of the predation activity of both ant species showed that *S. invicta* was significantly more successful (P=0.05; P-value=0.0001) in capturing 83.8% of the roaches compared to 50.7% by *P. dentata*. An evaluation of the number of roaches captured (Figure 1) relative to ant species and density showed that when *S. invicta* was present during eclosion, 100% of the roaches were captured. This capture rate occurred in four of the five ant colonies where the total mean density of ants ranged from 20.5 to 31.0. In the colony where all roaches escaped predation no ants were detected at the time of eclosion. Figure 1 also shows that during eclosion of roaches exposed to colonies of *P. dentata*, a 100% capture rate was observed in two with mean ant densities of 36.48 and 44.78. Partial predation (33.3%) occurred in one colony where the mean ant density was 3.0.

Table 1. Comparison of the capture rate of roaches to emerge from
P. americana oothecae in the presence of two ant species

		Number of roaches[1]				
Ant species[2]	Number oothecae	Captured		Escaped	%	Total
S. invicta	5	62	(8	12	(16.2)	74
P. dentata	5	36	(5	35	(49.3)	71

[1]Capture rates were significantly different (P-value = 0.0001; Z two sample t-test).
[2]Replicates of five colonies each.

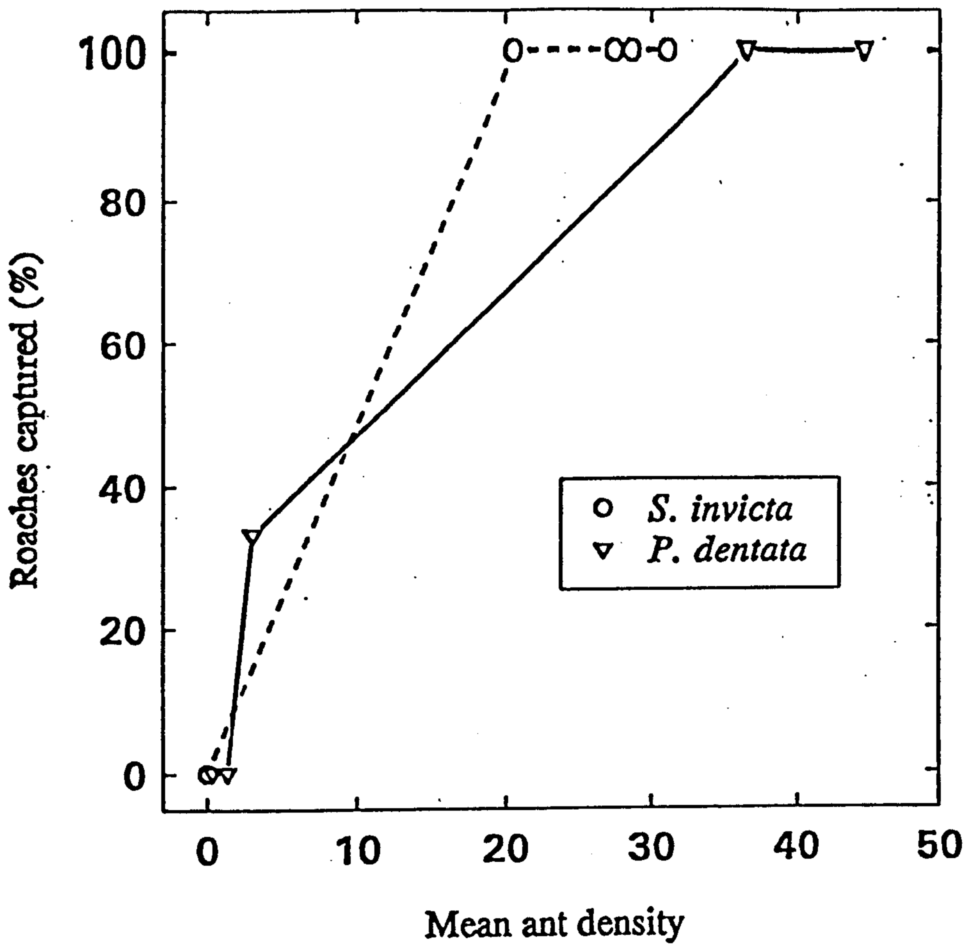

Figure 1. Percent of roaches captured during eclosion relative to mean ant density of *S. invicta* and *P. dentata*.

Of the remaining two colonies of *P. dentata* where the mean ant density was 0.33 and 1.33, all roaches escaped predation. From these results, there appears to be a threshold value for number of ants that must be present either on or near the *P. americana* egg cases in order to capture the roach nymphs.

Ant and Roach Interaction. In this analysis, those ant colonies that failed to forage within all the parameters tested were excluded. This was done to avoid a possible skew of the results which may have been caused by experimental error. Subsequently, of the ten ants colonies observed four *S. invicta* and three *P. dentata* were evaluated.

Observations were made on the behavior and interaction of *S. invicta* and *P. dentata* prior to, during, and following eclosion of *P. americana* ootheca (Table 2). Observations continued thereafter until ant activity and density returned to ca. preemergence levels. Beginning at -25 min to emergence of the first roach, results show a gradual increase in the density of both ant species. This increase was significant in the colonies of *S. invicta* within nine min from the initial opening of the ootheca suture and emergence of the first roach (P=0.05). The density of *P. dentata* increased significantly at 10 min before the first roach emerged which was also about the time of the initial opening of the ootheca suture. However, there were no significant differences in ant density between species during the preemergence time period.

When the first roach emerged, the density of *S. invicta* and *P. dentata* had increased ca. 2- and 4-fold, respectively. Given these results, it appears that the critical time for ant recruitment so as to minimize roach escape is ca. 9 to 10 min before emergence of the first roach nymph. Increased ant recruitment seems to have been triggered by the opening of the oothecae suture since roaches did not emerge until several min later. During the initial opening of the suture and prior to roach emergence or capture, ants of both species tended to use their head and mandibles to widen the suture and pull roaches prematurely from their egg cases. However, there was no evidence that either ant species could open the egg cases without the aid of hatching nymphs.

Table 2. Mean comparison (±SE) of numbers of ants[1] at times before, during, and after roach eclosion of *P. americana* oothecae

	S. invicta (n=4)		*P. dentata* (n=3)	
	Time (min)	Ant density	Time (min)	Ant density
		before initial roach emergence		
Preemergence	-25	4.00±2.4bA	-25	0.66±0.6bA
Preemergence	-20	5.75±2.6bA	-20	1.00±1bA
Preemergence	-10	7.00±2.9bA	-10	1.33±0.88bA
Initial opening of suture	-9	9.00±5.3bA	-6	6.33±5.8abA
First roach emerged	0	20.5±3.8aA	0	31.0±18.7aA
		after initial roach emergence		
Last roach emerged	+25	23.5±3.3aA	+10	25.3±11.2aA
Final removal of membrane	+69	19.0±6.4abA	+64	16.7±6.4aA
Ca. preemergence density	+412	5.25±3.8bA	+292	2.00±1.2aA

Means within a column followed by the same lowercase letter or means within a row followed by the same uppercase letter are not significantly different (P=0.05; Least Significant Differences).
[1]Number of ants observed on and off oothecae within a 6.9^2 cm area.

The mean elapsed time between emergence of the first and last roach was 25 min in the presence of *S. invicta* compared to 10 min in the presence of *P. dentata*. Again, differences in ant density between species during this time period were not significant. The ootheca suture closed on the protruding embryonic membrane when all live roaches had emerged or were captured. Immediately, the ants began to tear the membrane from the suture. They also entered the ootheca and removed the remaining membrane and dead roaches that failed to emerge. The mean removal time of the embryonic membrane was significantly greater for *S. invicta* than *P. dentata* although differences in densities between the species were not significant (P=0.05). The time required for *S. invicta* and *P. dentata* to return to their ca. preemergence density was 6.9 and 4.9 hr respectively.

B. Predation and interaction of *Solenopsis invicta* and *Pheidale dentata* on the endoparasitoid *Aprostocetus hagenowii* during preemergence and emergence from the ootheca of *Periplaneta americana* Linnaeus

Materials and Methods

Twenty or more *P. americana* ootheca, 1 to 2 days old, were collected from laboratory reared cockroach colonies. The oothecae were spread evenly in an open petri dish and maintained in a controlled environment (previously described). The oothecae were parasitized in the petri dish for a period of 5 days by placing them in a wide mouth one-half gallon clear plastic jar containing 60 or more unsexed *A. hagenowii* parasitoids. Subsequently each ootheca was placed in a gelatin capsule, dated, and held in a petri dish until within approximately 3 days of scheduled emergence. One egg case was randomly selected, glued to filter paper, and exposed to a colony of either *S. invicta* and *P. dentata* (previously described). A video camera (previously described) was used to record the results until parasitoid emergence was completed and foraging activities appeared normal. The following information was recorded: a) the number of ants present on the filter paper and on the oothecae prior to parasitoid emergence b) the number of parasitoids to emerge and escape predation, and c) a description of ant behavior on the filter paper prior to, during, and after parasitoid emergence. This experiment was replicated five times per ant species using different colonies. The control in the study was conducted by randomly selecting five parasitized *P. americana* oothecae (previously described) and gluing them in a cluster (without touching) on filter paper in the absence of ant colonies. A video camera (previously described) was focused on the five egg cases to record parasitoid emergence time, number, and activity.

Results and Discussion

Ant Density and Parasitoid Emergence Time. Table 3 shows a comparison of the mean density of *S. invicta* and *P. dentata* within 6.9^2 cm of *P. americana* ootheca during the initial emergence of *A. hagenowii* parasitoids. The mean numbers of *S. invicta* and *P. dentata* ants to walk "on" or make contact with *P. americana* egg cases when the first parasitoid emerged were not significantly different ($P = 0.05$; P-value = 0.086). Nor was there a significant difference between the two ant species ($P = 0.05$; P-value = 0.142) observed in mean numbers "off" *P. americana* oothecae within the 6.9^2 cm areas of evaluation.

Table 3. Comparison of the average number of ants within a 6.9^2 cm area of *P. americana oothecae* during the initial emergence of *A. hagenowii.*

Ant species[1]	Number oothecae	Mean number (± SE) of ants: On oothecae	Mean number (± SE) of ants: Off oothecae
S. invicta	5	7.2±1.46a	15.2±6.99a
P. dentata	5	4.0±1.55a	7.0±1.41a

Means ± standard error within a column followed by a common letter are not significantly different (P = 0.05; t-test).
[1]Replicates of five colonies each.

Table 4 provides a comparison of the overall mean emergence time of *A. hagenowii* from *P. americana* oothecae in the presence of *S. invicta* and *P. dentata*. Results show that the mean time for the last parasitoid to emerge when exposed to *S. invicta* was 8.96 ± 3.19 hr. This was significantly greater (P = 0.05) than for *P. dentata* or the control. However, the overall mean time required for *A. hagenowii* to emerge from *P. americana* ootheca in the presence of *P. dentata* was not significantly different (P = 0.05) from the control. Further analysis shows that the mean emergence time per parasitoid in the presence of *S. invicta* was 16.82 min and was significantly greater (P = 0.05) than the control (0.43 min). These differences clearly show that *S. invicta* is capable of delaying the overall mean emergence time of *A. hagenowii*. The delay was 39.1-fold.

Ant Predation and Parasitoid Emergence. Table 5 presents a comparison of the capture efficiency of *S. invicta* and *P. dentata* during emergence of *A. hagenowii* from *P. americana* ootheca. Results show that *S. invicta* captured approximately 10 percent more parasitoids than *P. dentata* and that the difference (P = 0.05; P-value = 0.0434) was significant. In summary, tables 4 and 5 strongly implicate *S. invicta* as having a greater negative impact on the survival and emergence time of *A. hagenowii* than *P. dentata*. The extent to which the significant delay (Table 4) in parasitoid emergence time can affect mating, synchronization, future progeny, and strategies for the implementation of biological control programs warrants further investigation.

Table 4. Comparison of the average emergence time of *A. hagenowii* from <u>*P. americana* ootheca in the presence of two ant species</u>

Ant species[1]	Number oothecae	Mean time (± SE) for last parasitoid to emerge (hours)	Mean time (± SE) per parasitoid to emerge (minutes)
S. invicta	5	8.96±3.19a	16.82±5.15a
P. dentata	5	3.02±1.08b	8.03±4.58ab
Control	5	0.12±0.05b	0.43±0.25b

Means ± standard error within a column followed by a common letter are not significantly different (P = 0.05; LSD test).
[1]Replicates of five colonies each.

Table 5. Comparison of the capture efficiency of *A.hagenowii* emergence from <u>*P. americana* ootheca in the presence of two ant species</u>

		Number of parasitoids				
Ant species[1]	Number oothecae	Captured[2]	%	Escaped	%	Total
S. invicta	5	118	(68.2)a	55	(31.8)a	173
P. dentata	5	123	(58.3)b	88	(41.7)b	211

[1]Replicates of five colonies each.
[2]Capture rates were significantly different (P-value = 0.0434; Z two sample t-test).

Ant and Parasitoid Interaction. Observations were made on the behavior and interaction of *S. invicta* and *P. dentata* prior to, during, and following eclosion of *P. americana* ootheca. *S. invicta* and *P. dentata* showed an increase in movement and frequency of contact with *P. americana* oothecae as early as 32 to 35 min, respectively, prior to initial emergence of the parasitoid *A. hagenowii*. Ant activity appeared to concentrate at the site where parasitoids would eventually emerge. Prior observations of parasitized oothecae under magnification showed that a viscous exudate nearly always appeared at the exit site prior to parasitoid emergence. Observations confirmed that the exudate attracted ant attention and is probably what increased ant attraction to the ootheca.

At the time of parasitoid emergence, both ant species attempted to pull the parasitoids from their exit hole. This aggressiveness in ant behavior often caused the emerging parasitoids to retreat back into the ootheca, thereby causing an overall delay in emergence time (Table 4).

Ants of both species were observed to enlarge and enter the ootheca through the parasitoid's exit hole before their final emergence. Minor workers usually entered first because of their small size relative to the parasitoid emergence hole size. Larger workers tended to chew on the exit hole until it was large enough for them to enter. In the case of the fire ant, this included major workers. However, the major workers of *P. dentata* rarely entered because of their larger head size and their inactivity in enlarging the hole. Ants that entered the ootheca removed the parasitoids that were slow to emerge or were dead.

Following parasitoid emergence or capture, ants continued to enter the exit hole to remove undetermined small particles and cast skins from the ootheca. Most of the contents removed were deposited on the filter paper while others were carried off. This activity was followed by a gradual decrease in ant density until ant behavior returned to preemergence level.

Summary

Laboratory studies confirmed that the red imported fire ant *S. invicta* and big-headed ant *P. dentata* are important predators of the cockroach oothecae. Their predation on cockroach oothecae caused significant mortality on hatching nymphs. Their aggressive interaction with the parasitoid *H. hagenowii* in the presence of their host oothecae showed *S. invicta* to cause a 13 fold reduction in parasitization. Both species demonstrated their ability to capture a significant number of *P. americana* cockroach nymphs and *A. hogenowii* parasitoids.

References Cited

Burns, E.C., and D.G. Melacon. 1977. Effect of imported fire ant (Hymenoptera: Formicidae) invasion on lone star tick (Acarina: Ixodidae) populations. J. Med. Entomol. 14:247-249.

Jamal, A. and J.M. Hugh. 1993. A review of the red imported fore ant (*Solenopsis invicta* Buren) and its impacts on plants, animals, and human health. Preventive Verterinary Medicine. 17:19-32.

Pimentel, D. 1995. Relationship of ants to fly control in Puerto Rico. Econ. Entomol. 48:28-30.

Pimentel, D., and L. Uhler. 1969. Ants and the control of house flies in the Philippines. J. Econ. Entomol. 62:248.

Sterling, W.L. 1978. Fortuitous biological suppression of the boll weevil by the red imported fire ant. Environ. Entomol. 7:564-568.

Summerlin, J.W. , J.K. Olson, R.R. Blume, A. Aga, and D.E. Bay. 1977. Red imported fire ant effects on *onthophagus gazella* and the horn fly. Environ. Entomol. 6:440-442.

ECOLOGY AND CONTROL OF THE ATTINE ANT *ACROMYRMEX LANDOLTI* IN A NEOTROPICAL SAVANNA.

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Field studies of spatial and temporal distribution of colonies of *Acromyrmex* landolti have provided insight into leafcutter ecology and contributed to development of a package of management recommendations for control of this leafcutter in the lowland savannas of eastern Colombia. Field studies also confirmed the presence of high levels of resistance to A. *landolti* in accessions of Brachiaria spp., the most important forage grass genus for the lowland tropics of Latin America. Laboratory and field studies have shown the mechanism of resistance to be inhibition of the attine symbiotic fungus. Aspects of field ecology and resistance studies are presented below. Field experiments were conducted at the Carimagua research station in the department of Meta, eastern Colombia.

Colony morphology

Colonies of A. *landolti* are small relative to the better known species of Atta, consisting of approximately 10^4 - 10^5 individuals and possessing a single colony entrance (Lapointe et al. 1993). Chambers containing fungus garden, brood or exhausted substrate are usually fewer than ten and generally located immediately below the entrance with the deepest chamber found as deep as 2 m during the dry season. Colony depth varies seasonally according to rainfall. During the rainy season (April - November), colonies are superficial with all chambers located within 15 cm of the surface. During the dry season (December - April), excavation of subsoil to the surface is evident thereby marking colony entrances. The depth of the deepest chamber during the dry season is approximately 2 m (Lapointe 1993).

Seasonal colony movement

Colony entrances were mapped yearly for va ious field experiments in areas of native savanna. Essentially all colonies relocated from one year to the next (Lapointe et al. 1993). The timing of colony migration, distance migrated and motive for migration are unknown.

Colony distribution

Mapping of colony entrances revealed an aggregated distribution explained by microtopological relief of the native savanna. Colonies were concentrated along slightly elevated ridges created by rainfall runoff parallel to the general slope. Contour maps of two sites were constructed using a surveyor's theodolite. Relative elevation was measured on a 10 x 10 m grid. For computer interpolation and generation of images, the datasets for each of two experiments consisted of counts of ant colonies per square meter of the experimental area with coordinates in meters for the quadrants and topographical data on a 10 meter grid for the same experimental area.

There was a microrelief correspondence with the occurrence of leafcutter colonies. Topographical data were interpolated from the ten meter grid to a meter pixel using a bicuadradic spline algorithm. The final analysis was made with the classes low (-60 to -30mm) med-low (-30 to 0mm), med-high (0mm to +30mm) and high (+30mm to +60mm including some readings up to 120 mm). An analysis of deviance was conducted on the combined data from the two trials. The residual values generated by the bicuadratic spline algorithm were plotted and resulted in an image of microrelief with general slope removed. Colony distribution was superimposition on the residuals. High colony density coincided with raised "ridges" that run parallel to the general slope. Microrelief height classes of the combined data were significantly correlated with colony density. Colony density was highly aggregated on the areas within the higher height classes. We attribute the existence of the observed microrelief patterns to the action of surface runoff during the seasonally heavy rains although there may be a more complex relationship between leaf-cutter activity, soil removal, botanical composition, and runoff.

A simulated sampling study showed that orienting the sample quadrat perpendicular to the slope reduced variance by more than half. Variance was also reduced by changing the shape of the original quadrat from 4x50 to 2x100m. In the field, an individual can conveniently scan a width of one meter while walking along a transect line. The original shape was determined arbitrarily assuming a random distribution. As the mean distance between ridges of high density was approximately 60m, variance is reduced by extending the length of the sampling unit so that in every quadrat at least one area of high and one area of low density is included in samples perpendicular to the slope. Due to the irregular spatial distribution of colonies and due to the absence of colonies in neighboring relatively vacant areas despite available food resources, we conclude that the observed aggregated distribution is not a result of intraspecific competition. However, competition may be occurring for nesting sites in the better drained areas.

Plant resistance to leafcutters in *Brachiaria* spp.

Four measures of plant resistance to *A. landolti* were assessed: resistance in seedlings to cutting during establishment; rate of colonization by *A. landolti* over a three year period subsequent to establishment; effect of cultivars on field colony fungal garden weight; and inhibition of growth of the fungal symbiont on nutrient medium (Lapointe et al. 1995).

Table 1. Attributes of five tropical forage grass cultivars evaluated for resistance to the leafcutter *Acromyrmex landolti*.

Species/Cultivar	Seedling resistance[1]	Colonization rate[2]	Fungal garden weight in field[3]	Fungal growth in vitro[4]
Andropogon gayanus 'Carimagua 1'	S	High	High	High
Brachiaria dictyoneura 'Llanero'	S	High	High	High
B. decumbens 'Basilisk'	R	Low	Low	Low
B. humidicola 'Pasto Humidicola'	R	Low	Low	Low
B. brizantha 'Marandú'	R	Low	Low	Low

[1] S, susceptible; R, resistant to cutting in field during germination.
[2] Rate of colonization by *A. landolti* of fully established swards over three years.
[3] Weight of fungus excavated from colonies restricted to cutting a single cultivar for 30 d.
[4] Effect of whole leaf homogenates on fungal growth on nutrient agar.

Two cultivars, the known susceptible *Andropogon gayanus* 'Carimagua 1' (CIAT 621) and *Brachiaria dictyoneura* 'Llanero' (CIAT 6133) suffered greater seedling loss to leafcutters during establishment, were more heavily colonized subsequent to establishment, and afforded high rates of fungus growth in the field and in vitro. It was concluded that inhibition of the attine fungal symbiont is the mechanism of resistance to leafcutters operating in the forage genus *Brachiaria*. A bioassay based on inhibition of the symbiont was developed for selection of cultivars and hybrid progeny for an ongoing *Brachiaria* breeding effort at CIAT (Lapointe et al. 1995). Based on these and other findings, a set of management recommendations was developed based on estimates of colony density and characterization of resistance of commercial cultivars to *A. landolti* (Lapointe 1993).

Literature Cited

Lapointe, S. L., M. S. Serrano & I. I. Corrales. (1995). Resistance to the attine ant Acromyrmex landolti (Forel) and inhibition of its fungal symbiont by tropical forage grasses. (submitted to J. Econ. Entomol.)

Lapointe, S. L., M. S. Serrano & A. Villegas. 1993. Colonization of two tropical forage grasses by Acromyrmex landolti (Hymenoptera: Formicidae) in eastern Colombia. Fla. Entomologist. 76: 359 - 365.

Lapointe, S. L., C. A. García & M. S. Serrano. 1990. Control of Acromyrmex landolti in improved pastures in the Colombian savanna, pp. 511 - 518. In R. K. Vander Meer, K. Jaffe, and A. Cedeño [eds.], Applied myrmecology: a world perspective. Westview Press, Boulder, Colorado.

Lapointe, S. L. 1993. Manejo de dos plagas claves para forrajes de las sabanas neotropicales. Pasturas Tropicales 15(3): 1-9.

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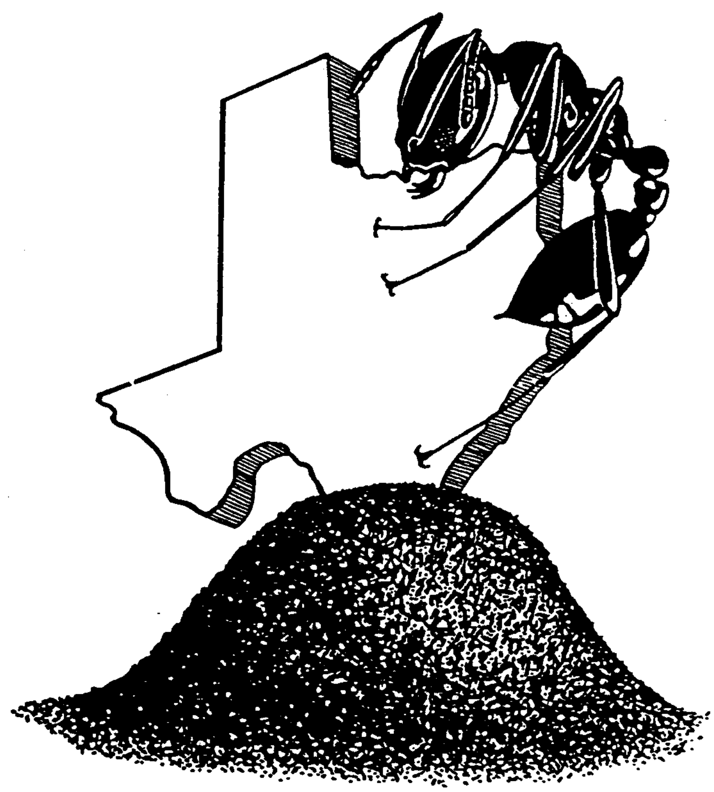
ANNUAL
IMPORTED FIRE ANT CONFERENCE



Invasion and Range Expansion of Imported Fire Ants in North America From 1918 - 1993

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INTRODUCTION

The first imported fire ant identified in the United States was the black imported fire ant *Solenopsis saevissima richteri* Forel (Loding 1929). Creighton (1930) estimated the arrival of *S. richteri* to be around 1918 through the port of Mobile, AL. A second species, the red imported fire ant *Solenopsis invicta* Buren, also arrived through the port of Mobile, AL sometime between 1933 and 1945 (Lennartz 1973). The fact that there were two separate species present in the United States was not fully recognized until Buren (1972) revised the taxonomy for the imported fire ants. More recently, it has been discovered that a hybrid form of the two species also exists (Vander Meer & Lofgren 1985, Diffie et al. 1988).

Information and data relative to the range expansion of the imported fire ants, *S. richteri* Forel and *S. invicta* Buren, is scattered throughout the literature. Several authors have examined range expansion through 1953 to 1974 (Culpepper 1953, Wilson & Brown 1957, George 1958, Adkins 1970, Buren et al. 1974). More recent authors have briefly reviewed range expansion before discussing the history of imported fire ant control (Lofgren 1986) or quarantine (Lockley & Collins 1990). This document is not intended to speculate on possible future range expansion, but to compile all known information on range expansion of imported fire ants into one source.

MATERIALS AND METHODS

In order to accomplish our objective, several "ground rules" were established.

1. The overall expansion of all imported fire ants was established; expansion of individual species or their hybrid was not differentiated.

2. Over the years, the federal imported fire ant quarantine (Code of Federal Regulations, Title 7, Section 301.81 - hereafter cited as CFR has listed the affected areas in a variety of ways: regulated areas, generally infested areas, eradication areas, suppressive areas, and quarantined areas. For our purposes, we consider any county/parish listed in the CFR as an infested area.

3. Pockets of infestations may be present in any given year outside the area listed in the CFR for that year. As these areas are not cited in any consistent manner, they were not included.

4. In determining the total number of acres infested per year, total acreage infested per county/parish was extrapolated from the literature for 1918-1953 (Table 1). From 1958-1993, all data came from the annual CFR, and total acreage of an infested county/parish was used regardless of whether the county/parish was entirely or partially infested. County/parish acreage was obtained from Rand McNally (1993).

5. As stated above, from 1958-1993, the CFR is used as the sole reference for range expansion of the imported fire ant. However, in some years, no additions were made to the manual. In those years, it is unknown if new areas meeting the criteria necessary for inclusion in the federal quarantine were not found, or if no surveys were conducted due to lack of manpower or funds.

DISCUSSION

From its small toehold in Mobile, AL in 1918, imported fire ants spread over 62,448,000 acres into all or part of 141 counties/parishes in eight states by 1958. In 1993, the pest had expanded its range to a total of 275,637,120 acres in all or part of 651 counties/parishes in 11 states and Puerto Rico.

Table 1. Extrapolation Method for Estimating Acres Infested with Imported Fire Ant

YEAR	ACRES	REFERENCE	EXTRAPOLATION METHOD
1918	1	Creighton 1930	pers. commun. from Loding - ant appeared in Mobile, AL ca 1918 - we estimated at arrival, ant infested ca 1 acre around the port of Mobile
1930	24,630	Creighton 1930	per. observ. of Creighton - infestation extended 6-7 miles from Mobile - we assumed infestation radiated out from the port of Mobile, making a circular pattern around the port with a diameter of 7 miles; area = Πr^2 = 38.48 sq. miles
1939	4,820,800	Adkins 1970	12 counties infested - 2 FL, 3 MS, 7 AL - map in reference indicates counties - we assumed only the counties completely surrounded by other infested counties were fully infested and all others are partially infested; i.e. fully infested = total county acreage partially infested = 0.5 county acreage; all county acreage obtained from Rand McNally (1993)

YEAR	ACRES	REFERENCE	EXTRAPOLATION METHOD
1953	12,768,669	Culpepper 1953	listed counties and described area infested - we assumed: entire county = total county acreage corner or portion (ex. SE corner) = 0.25 county acreage corner or portion (ex. southern corner) = 0.5 county acreage nursery = average size of nursery in that state in 1950 as documented by Hurley (1952) - avg. no. acres in field grown stock, does not include material grown under glass or in houses area around a cited town = sq. miles of township in 1960 as documented by Area Measurement Reports (1960) - towns of <1000 people not listed and therefore arbitrarily assigned 0.5 sq. miles (smallest town listed in reference = 0.6 sq. miles)
1958	62,448,000	1958 7CFR §301.81-2a	counties are listed as partially or fully infested but partial boundaries would have been difficult to accurately determine for all counties over 35 years, therefore total county acreage was used regardless of amount of county infested
1964	105,354,240	1964 7CFR §301.81-2a	see 1958
1969	141,587,200	1969 7CFR §301.81-2a	see 1958
1974	176,914,560	1974 7CFR §301.81-2a	see 1958

YEAR	ACRES	REFERENCE	EXTRAPOLATION METHOD
1979	221,641,600	1979 7CFR §301.81-2a	see 1958
1984	233,144,320	1984 7CFR §301.81-2a	see 1958
1989	263,137,920	1989 7CFR §301.81-2a	see 1958
1993	275,637,120	1993 7CFR §301.81-3e	see 1958

Table 2. Important dates in the Federal Imported Fire Ant Quarantine.

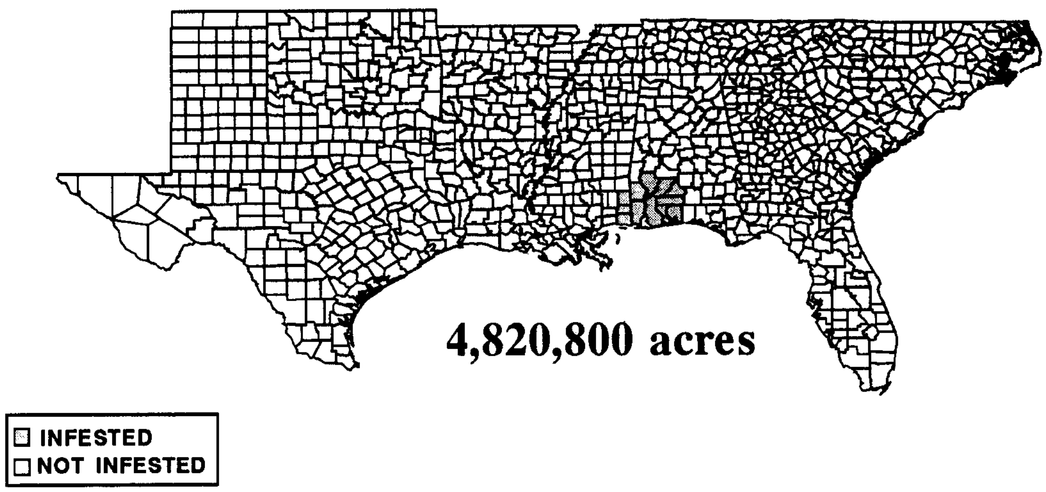
DATE	EVENT
1958	Inception - all or part of 8 states quarantined (AL, AR, FL, GA, LA, MS, SC, TX)
1971	NC added
1973	all of LA under quarantine (1 parish partial until 1975)
1976	all of FL under quarantine
1983	Puerto Rico added
1988	OK added all of AL under quarantine (1 county partial until 1992)
1990	TN added

Table 3. Increase in Number of Acres Infested from Inception of Quarantine in 1958 through 1993.

YEAR	MEAN INCREASE IN NUMBER ACRES INFESTED/YR ± SEM	NO. YEARS WITH ZERO INCREASE
1958-1977	8,173,170.53 ± 1,362,211.80a	3
1977-1993	3,618,680.00 ± 1,361,789.64b	5
1958-1993	6,091,117.71 ± 1,014,131.39	8

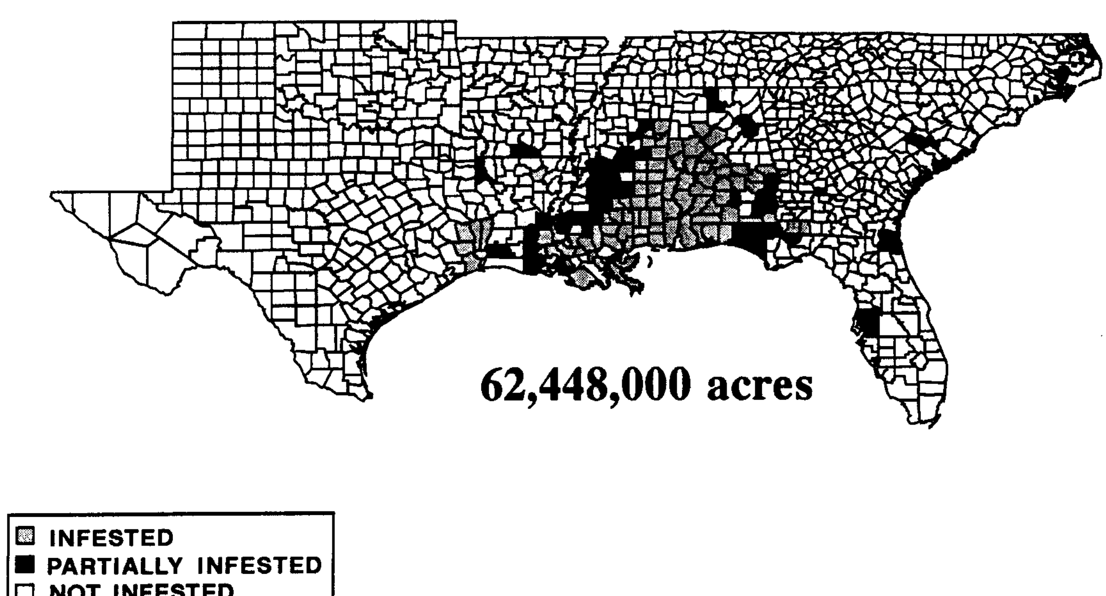
Means followed by the same letter are not significantly different according to a t-test (df=33, P=0.05).

INFESTED COUNTIES - ca 1939
Adkins 1970*



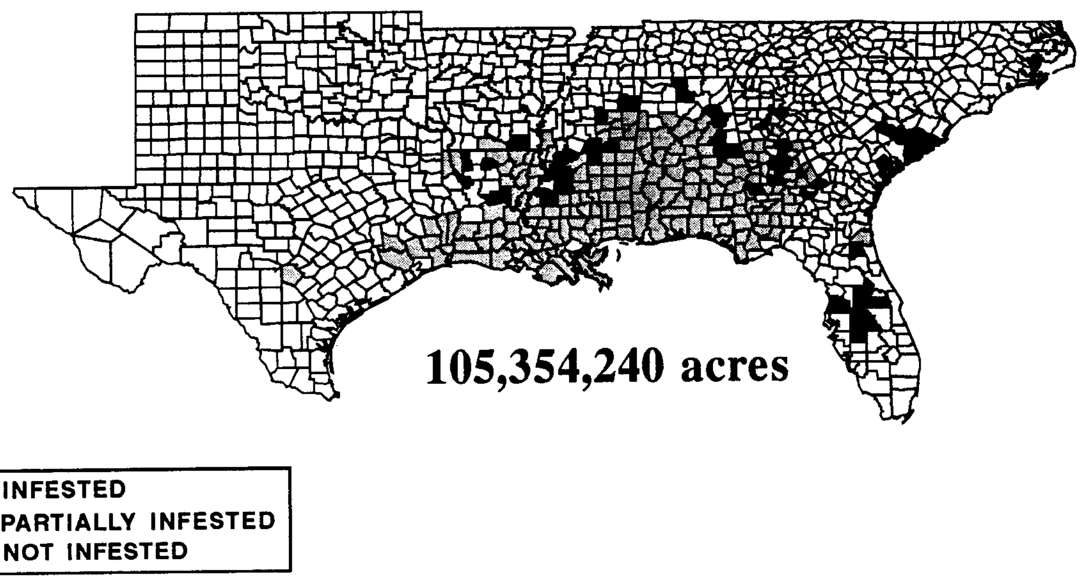
* did not differentiate between whole and partial infestations

IMPORTED FIRE ANT QUARANTINE - 1958
7CFR §301.81-2a effective May 6, 1958



IMPORTED FIRE ANT QUARANTINE - 1964

7CFR §301.81-2a effective August 27, 1964



IMPORTED FIRE ANT QUARANTINE - 1974

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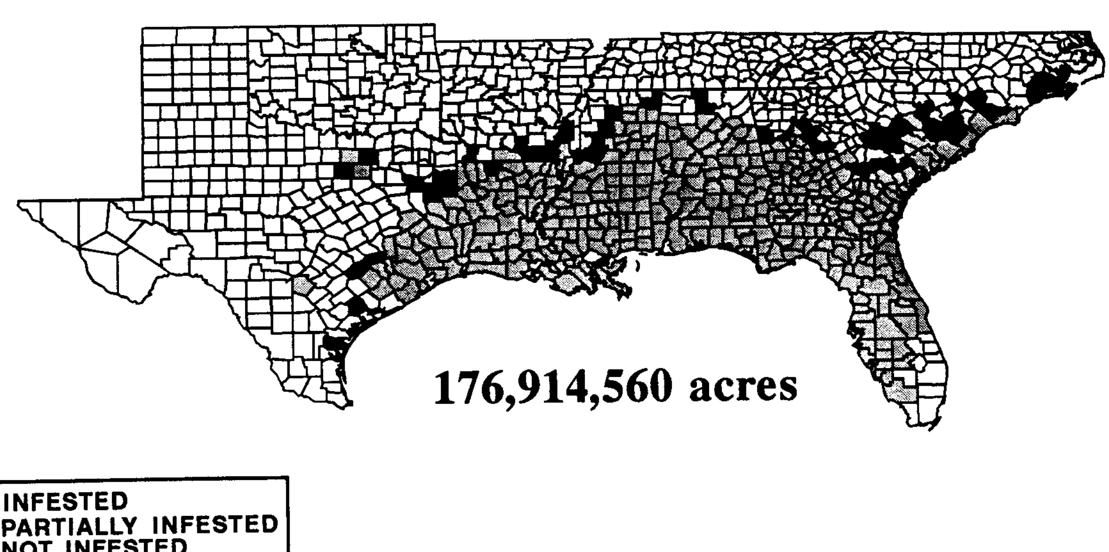
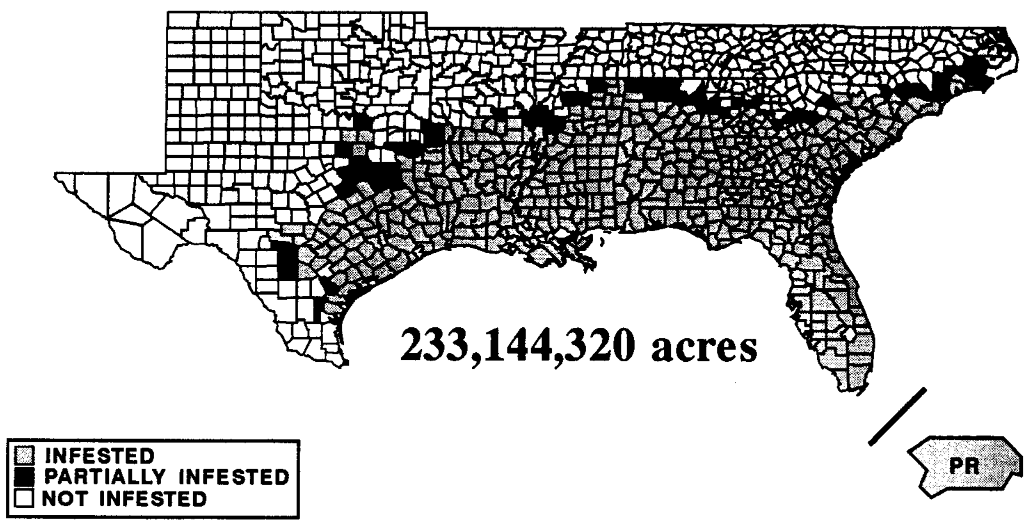


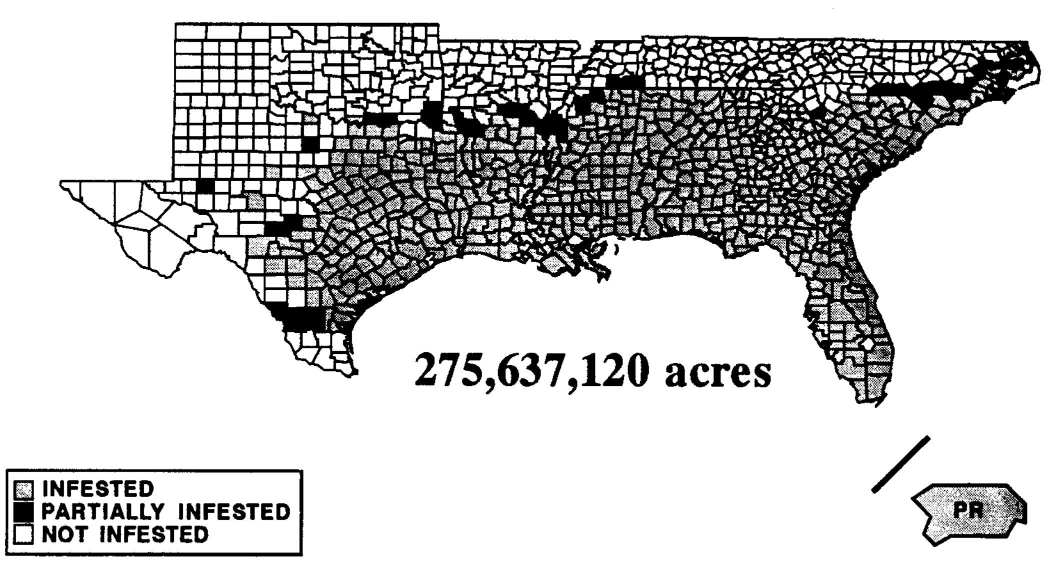
IMPORTED FIRE ANT QUARANTINE - 1984

7CFR §301.81-2a



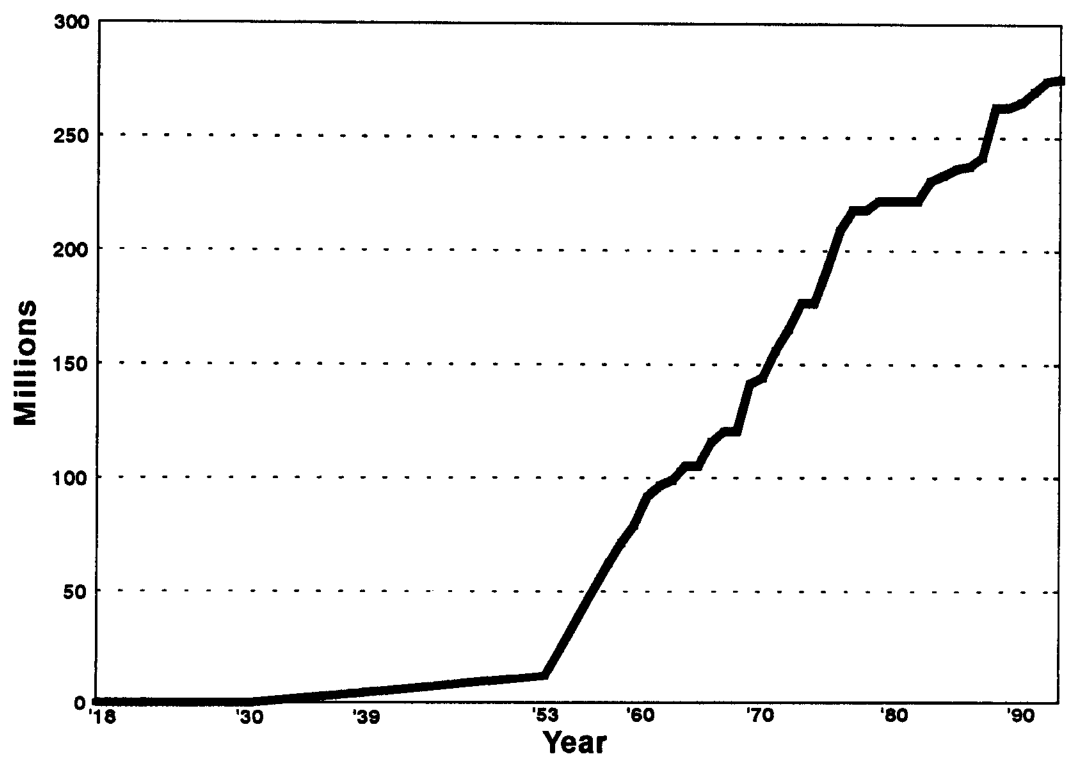
IMPORTED FIRE ANT QUARANTINE - 1993

7CFR §301.81-3*



* 7CFR §301.81 was revised Dec. 4, 1992, effective Jan. 4, 1993

Number of Acres Infested by Imported Fire Ants From 1918 - 1993



REFERENCES CITED

Adkins, H.G. 1970. The imported fire ant in the southern United States. Ann. Assoc. Amer. Geographers. 60: 578-592.

Area Measurement Reports. 1960. U.S. Dept. of Commerce. Bureau of the Census. Series GE-20. Areas of [State]: 1960. No. 2, 11, 20, 26.

Buren, W.F. 1972. Revisionary studies on the taxonomy of the imported fire ants. J. Ga. Entomol. Soc. 7: 1-25.

Buren, W.F., G.E. Allen, W.H. Whitcomb, F.E. Lennartz & R.N. Williams. 1974. Zoogeography of the imported fire ant. N.Y. Entomol. Soc. 82: 113-124.

Creighton, W.S. 1930. The new world species of the genus *Solenopsis* (Hymenoptera: Formicidae). Proc. Amer. Acad. Arts & Sci. 66: 39-151.

Culpepper, G.H. 1953. Status of the imported fore ant in the southern states in July 1953. U.S.D.A., Bur. Entomol. & Plant Quar. Special Rpt. E-867. Washington DC.

Diffie, S., R.K. Vander Meer & M.H. Bass. 1988. Discovery of hybrid fire ant populations in Georgia and Alabama. J. Entomol. Sci. 23: 187-191.

George, J.L. 1958. The program to eradicate the imported fire ant. Report to the Conserv. Found. and the N.Y. Zool. Soc. 39 pp.

Hurley, R. 1952. U.S. census of agriculture: 1950. Special Rpts. Horticultural specialties. U.S. Dept. of Commerce. Bureau of the Census. Vol. V. Part I. U.S. Government Printing Office.

Lennartz, F.E. 1973. Modes of dispersal of *Solenopsis invicta* from Brazil into the continental United States - a study in spatial diffusion. MS Thesis. Univ. of Florida, Gainesville. 242 pp.

Lockley, T.C. & H.L Collins. 1990. 6. Imported fire ant quarantine in the United States of America: past, present, and future. J. Ms. Acad. Sci. 35: 23-26.

Loding, H.P. 1929. An ant (*Solenopsis saevissima richteri* Forel). Insect Pest Survey Bull. 9: 241.

Lofgren, C.S. 1986. History of imported fire ants in the United States, pp. 36-47. *In* C.S. Lofgren & R.K Vander Meer [eds.], Fire ants and leaf-cutting Ants. Westview Press, Boulder, CO.

Rand McNally. 1993 Commercial atlas and marketing guide. 124th ed. Rand McNally & Co., U.S.A.

Vander Meer, R.K. & C.S. Lofgren. 1985. Biochemical evidence for hybridization in fire ants. Fl. Entomol. 68: 501-506.

Wilson, E.O. & W.L. Brown, Jr. 1957. Recent changes in the introduced population of the fire ant *Solenopsis saevissima* (Fr. Smith). Evolution. 12: 211-218.

Studies of an Imported Fire Ant Population in Eastern Tennessee.

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INTRODUCTION

Red imported fire ants (RIFA); *Solenopsis invicta,* currently infest over 275,000,000 acres in 11 states and Puerto Rico. A congener species, S. *richteri,* inhabits a relatively small area in northwestern Alabama, northeastern Mississippi, and southern Tennessee. Interbreeding between S. *invicta* and S. *richteri* results in the production of a fertile hybrid form. Range expansion continues primarily by S. *invicta* and the hybrid form, by both natural and artificial means. Recent isolated infestations in Phoenix, AZ (Collins unpublished), Virginia (Waller 1993), and Tennessee (Milam unpublished), suggest that fire ants are becoming acclimated to harsh environments and continued range expansion may result. Some scientists have speculated that hybrid vigor may enable the hybrid to survive in colder areas than the parental forms.

In December 1992, an isolated 3,000 acre infestation was discovered near the town of Calhoun, TN approximately 45 miles northeast of Chattanooga, TN. **A** wood pulp processing plant appeared to be the source of the infestation. The original infestation may have been introduced onto the plant site on construction equipment or material. This population appears to be well adapted and thriving. To learn more about this isolated population, several ecological studies were initiated in 1993. We report here preliminary data. The final results of these studies may offer better estimates of the ultimate range of imported fire ants.

MATERIALS AND METHODS

Four studies were established, winter lull, seasonal life cycle, survivability of incipient colonies/newly mated queens under sub-optimal temperatures, and impact of RIFA on local ant fauna were determined.

WINTER KILL: Survival of colonies in the Calhoun, TN, infestation were compared to a control site at Gulfport, MS. Population estimates in eight 0.25 acre test plots were made in October 1993 at each site using the population indexing system described by Harlan et al. (1981) and modified by Lofgren and Williams (1982).

Test plots were re-evaluated in April, July and October, 1994 and April, 1995. Maximum and minimum temperatures, humidity, rainfall, and soil temperatures were collected at both sites. Mean number of colonies present at each site was compared with a t-test, as were mean population indices.

SEASONAL LIFE CYCLE: Markin and Dillier (1971) reported on the seasonal life cycle of RIFA along the Gulf Coast of Mississippi. Techniques and procedures used in that study were utilized to compare life cycle of RIFA in Calhoun, TN with Gulfport, MS. Briefly, those procedures consisted of making monthly collections of field colonies of RIFA (n=4) and using the desiccation technique described by Markin (1968) to separate all life stages of the ant from the associated nest tumulus. Separated colonies were then preserved in isopropyl alcohol in 500 ml high density polyethylene bottles. The preserved colonies were thoroughly mixed using a magnetic stirrer, and while the solution was mixing, a 5 ml subsample removed by dipping a teaspoon into the mixture 3-6 time. Each spoonful was placed into a calibrated beaker with a screen bottom. This allowed the alcohol to drain anda 5 ml ant subsample to be collected. The 5 ml subsample was then placed on filter paper and the excess alcohol drawn off through a Buchner funnel. Finally, each subsample was dried under a hood for 1 hr prior to evaluation. Each life stage present was then enumerated. From this data, the percentage of all life stages present in each sample date was determined for each location.

SURVIVABILITY OF QUEENS & INCIPIENT COLONIES UNDER SUBOPTIMAL TEMPERATURES IN THE LABORATORY: This portion of the study is being conducted at USDA, ARS, MAVERL, in Gainesville, FL. Bioclimatic chambers programmed for sub-optimal developmental temperatures (Williams 1990) were used to compare nesting success of ants collected near Calhoun, TN with those collected in Gainesville, FL. Newly mated queens were collected following mating flights. Also, small incipient colonies were field collected by shovelling the entire nest tumulus into plastic pails. Ants were then transported to Gainesville FL for laboratory rearing in the chambers. Colonies were subjected to temperature regimes that mimic average monthly conditions in several U.S. cities including Calhoun, TN (negative control), Gainesville, FL (positive control), Nashville, TN, Washington D.C., and St. Louis, MO. Nesting success was based on colony development rates (colony weight per time). An analysis of variance was used to compare development rates among the various temperature regimes and collection locations.

IMPACT OF RIFA ON LOCAL ANT FAUNA: Fire ants readily compete with different arthropod species including other ants (Porter & Savignano 1990). Ant species diversity in the RIFA infested area of Calhoun, TN was compared with a non-infested control area of similar or identical habitat approximately 10-20 miles from the RIFA infested area. Collections were made at monthly intervals for the length of the study. Two collection procedures were utilized.

Bait transect: Transects, 200 meters in length (n=4), were placed in similar habitats at both infested and uninfested sites, i.e. open fields, old field successional habitats, etc. These transects were used for both bait and pitfall traps. Bait and pitfall stations were alternated along each transect at 5-m intervals. Each bait transect was comprised of 10 bait stations, five baited with canned sausage and five baited with maple syrup. Baits were placed in snap-top vials and left in place for 1 hr prior to collecting. Collections were immediately frozen and returned to the IFA laboratory in Gulfport, MS for sorting and identification. Bait transects will provide a measure of the abundance and diversity of ants that might compete for food resources with RIFA.

Pitfall traps: Pitfall traps were also employed to collect ants and other arthropods in both the RIFA infested site and a nearby non-infested site. These traps will indicate the abundance and diversity of ants and other arthropods that may not be attracted to the diurnally placed baits used in the bait transect. A total of 10 pitfall traps located along the 200 meter transect were utilized at each site. Each transect traversed similar habitats and efforts were made to include as much habitat diversity as possible. Permanent type pitfalls were utilized. Pitfall traps at each site consisted of test tubes containing 70% ethanol placed in preset PVC sleeves spaced 10 meters apart along the transect. Traps were collected ca. 24 hrs after placement. All samples from the site were composited. placed in a 50 cc polyethylene bottles. and mailed to the IFA laboratory in Gulfport, MS, for sorting and identification.

The number of ant species in the RIFA-infested and non-infested sites were compared by chi-square analyses. Ant abundance will be compared by analyses of variance or analogous nonparametric tests.

RESULTS

WINTER KILL: Winter kill data collected thus far has been compiled. Both sites in October 1993 had similar population indices and numbers of colonies present (Figures 1&2). By April 1994 the Tennessee site had significantly lower IFA populations and colony numbers compared with the Mississippi site, indicating notable winter kill. These Tennessee populations did not rebound as expected over the summer months, but remained at very low levels. The Mississippi site showed a large reduction in population index and number of colonies at the July 1994 assessment. This mid-summer drop in IFA populations appears to be a natural phenomenon in the hot dry summer climate of south Mississippi (Collins & Lockley, pers. obs.). Populations had rebounded well by the October 1994 counts. Assessments at both sites will continue for the course of the study.

SEASONAL LIFE CYCLE: The dramatic reduction in IFA colonies in the Tennessee plots over the winter of 1993-1994 made colony collection for this portion of the study somewhat difficult. In February and June, 1994, no colonies were collected. In May, 1994 only three colonies were evaluated to determine life stages present, and in July, 1994 only two colonies were evaluated. Gravid females and eggs were rarely collected. The biology of the insect precludes easy collection of gravid females and our extraction technique may be the cause of the low egg numbers. The mesh screens used in the process may not have been fine enough to retain all the eggs in the samples.

Preliminary life stage data shows some interesting trends. In the immature forms, small larvae were produced year round with a drop in production in the winter months (January-March) at both sites (Figures 3&4). At the Mississippi site, there was a cessation in worker pupae production in January, 1994, while the Tennessee site ceased worker pupae production for three winter months. Minor workers were the most abundant life stage year round in both sites. The most interesting trend at this time is that of the alate females. At the Tennessee site alate females were collected year round, while at the Mississippi site, where climatic conditions seem more suitable for continuous alate female production, no alate females were collected December, 1993 through February, 1994.

SURVIVABILITY OF QUEENS & INCIPIENT COLONIES UNDER SUBOPTIMAL TEMPERATURES IN THE LABORATORY: Eight alate queens in Chattanooga, TN were sent by overnight mail to Gainesville, FL in June, 1994. Alate queens were collected in Gainesville within a week of receiving the Tennessee queens. When eggs were observed, queens from each location were placed in temperature chambers that followed the average monthly temperatures of either Orlando, FL, or Chattanooga, TN. After 3 months, the Florida queens had produced small colonies under both temperature regimes, but all the eggs from the Tennessee queens did not hatch or were eaten. It was assumed that the Tennessee queens had not mated and the study was terminated. We plan to collect additional newly-mated queens and incipient colonies and continue this study.

IMPACT OF RIFA ON LOCAL ANT FAUNA: Ant species diversity in the RIFA infested area of Calhoun, TN was lower than species diversity in the RIFA non-infested (control) area located approximately 10-20 miles away. Collections from both procedures, bait transects (protein and sugar baits) and pitfall traps, indicated that greater numbers of other ant species were collected in the uninfested sites than were collected from sites containing fire ants.

SUMMARY

Fire ant colony populations decreased during the winter in Tennessee; some colonies survived although the winter was considered to be a severe one. Worker pupae production ceased for three months in the winter for Tennessee colonies but for only one month in Mississippi. The Tennessee fire ant workers were able to survive better for short periods of time at 2C° than fire ant workers collected in Florida. A greater number of other species of ants were collected outside the fire ant infested sites indicating that fire ants may have a negative effect on the diversity of the ant fauna in Tennessee.

LITERATURE CITED

Harlan, D.P., W.A. Banks, H.L. Collins, and C.E. Stringer. 1981. Large area test of AC-217,300 bait for control of imported fire ants in Alabama, Louisiana, and Texas. Southwest Entomol. 6:150-157.

Lofgren, C.S. and D.F. Williams. 1982. Avermectin B1a, a highly potent inhibitor of reproduction by queens of the red imported fire ant. J. Econ. Entomol. 75: 798-803.

Markin, G.P. 1968. Handling techniques for large quantities of ants. J. Econ. Entomol. 61: 1744-1745.

Markin, G.P. and J.H. Dillier. 1971. The seasonal life cycle of the imported fire ant, *Solenopsis saevissima richteri*, on the Gulf coast of Mississippi. Ann. Entomol. Soc. Amer. 64: 562-565.

Porter, S.D. and D.A. Savignano. 1990. Invasion of polygyne fire ants decimates native ants and disrupts arthropod community. Ecology. 71: 2095-2106.

Waller, D. 1993. Current status of fire ant infestations in Virginia. *In*: Proceedings, 1993 Imported Fire Ant Conference, 15-18 June 1993. Charleston, SC.

Williams, D.F. 1990. Oviposition and growth of the fire ant, *Solenopsis invicta*, pp. 150-157. *In*: R.K. Vander Meer, K. Jaffe, and A. Cedeno [Eds.], Applied Myrmecology: a world perspective. Westview Press, Boulder, CO.

Figure 1. Changes in IFA Population Indices at two different sites over 18 Months

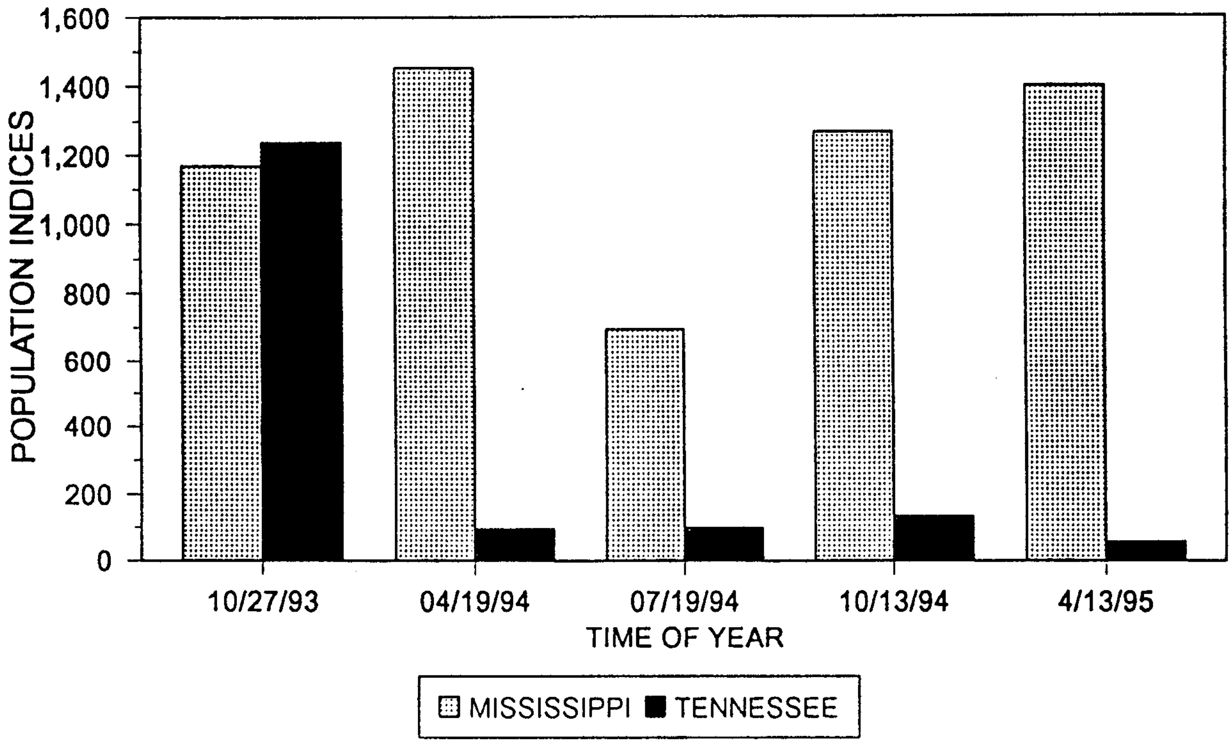


Figure 2. Changes in Mean Number of IFA Colonies at two different sites over 18 Months

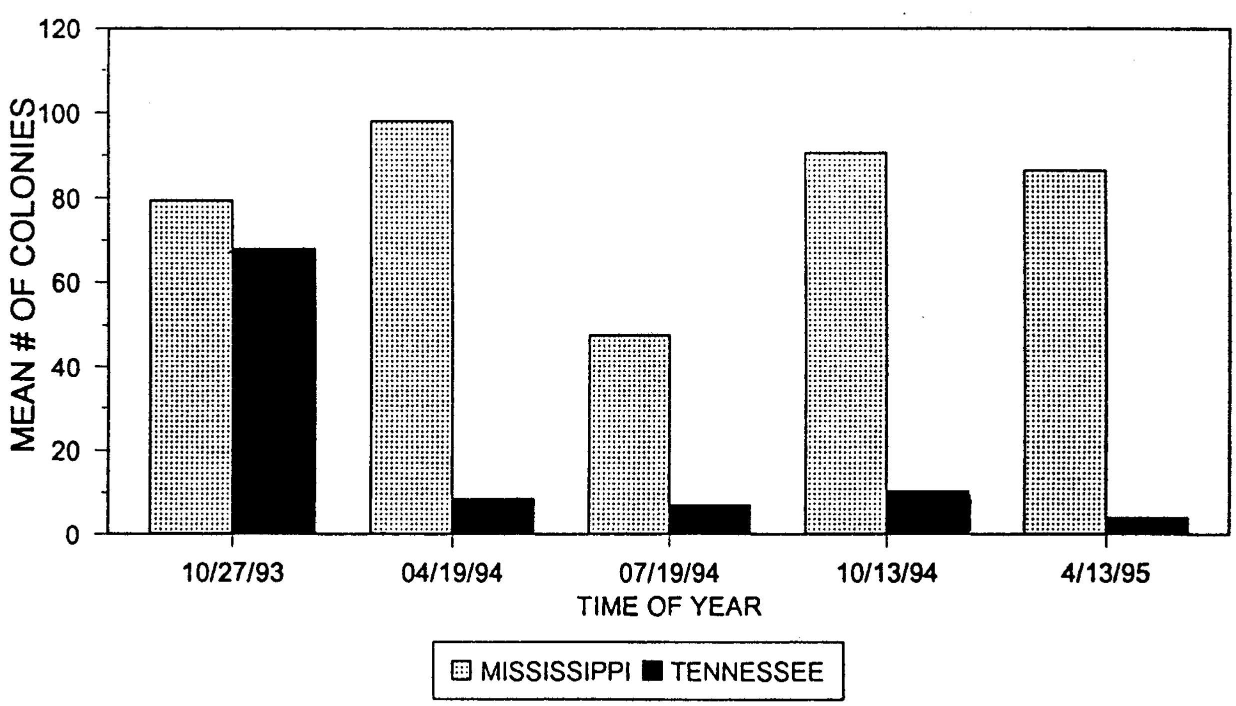


Figure 3. Percent of Immature Stages Found in Mississippi Colonies

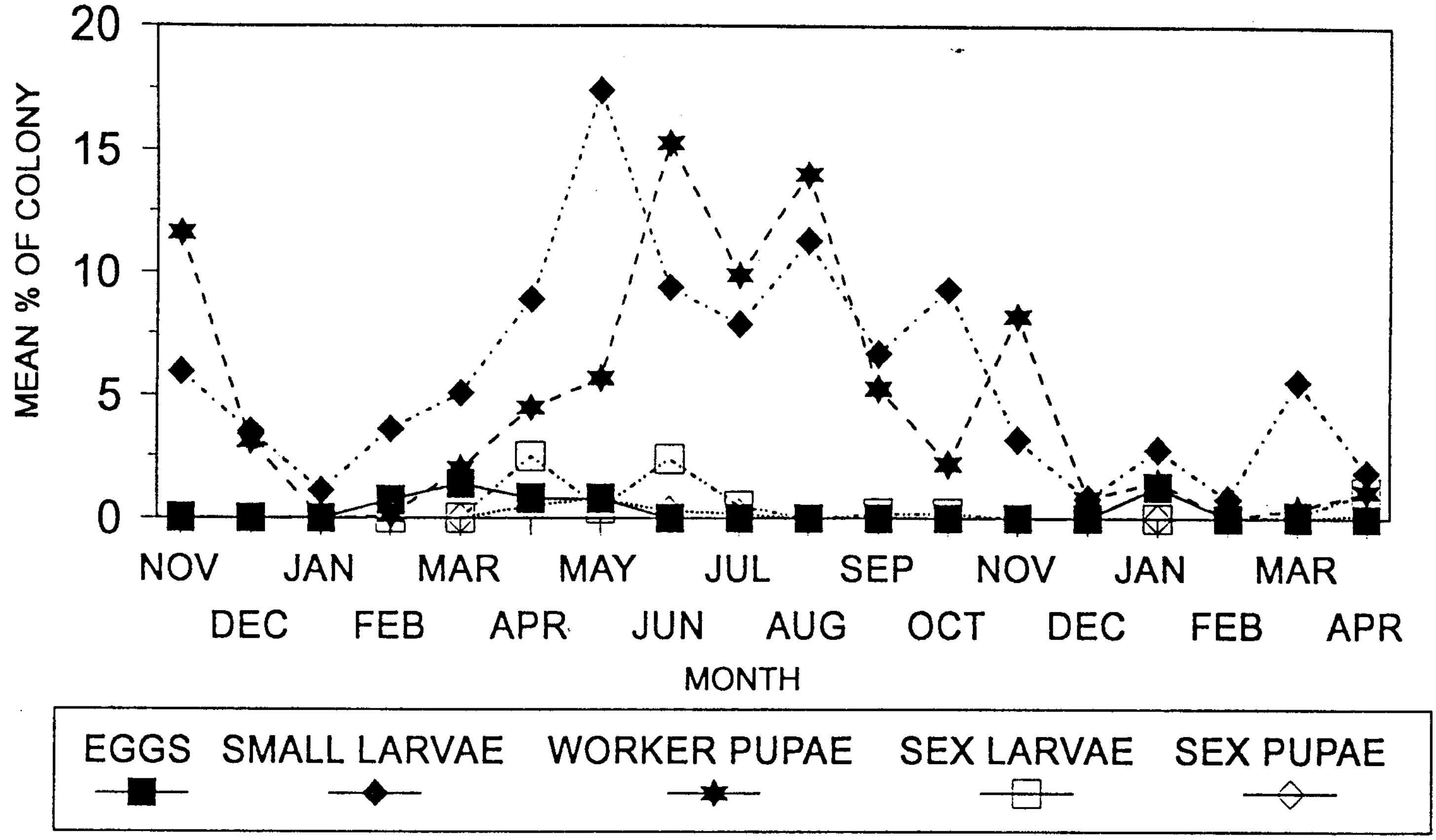


Figure 4. Percent of Immature Stages Found in Tennessee Colonies

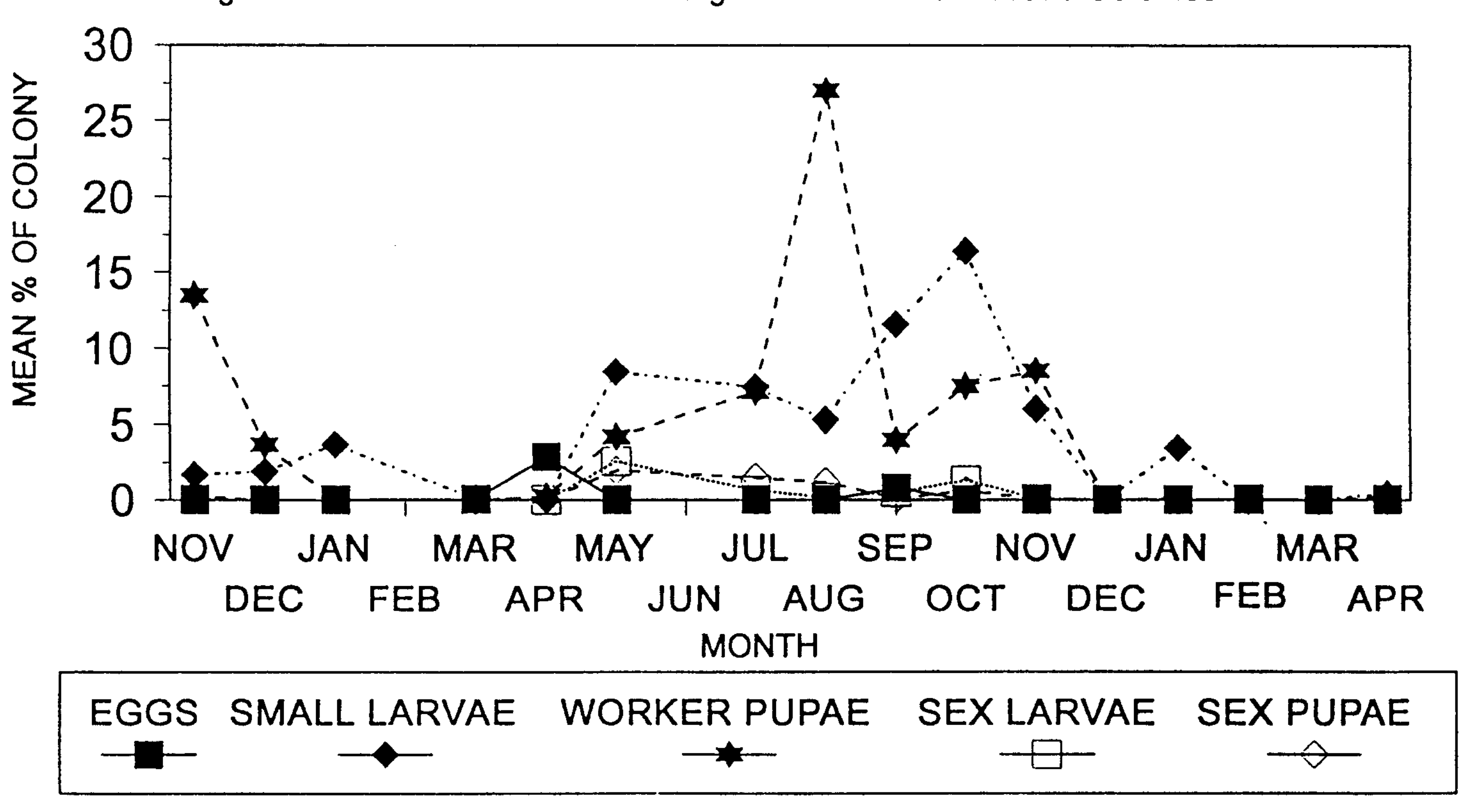


Figure 5. Percent of Adults Found in Tennessee Colonies

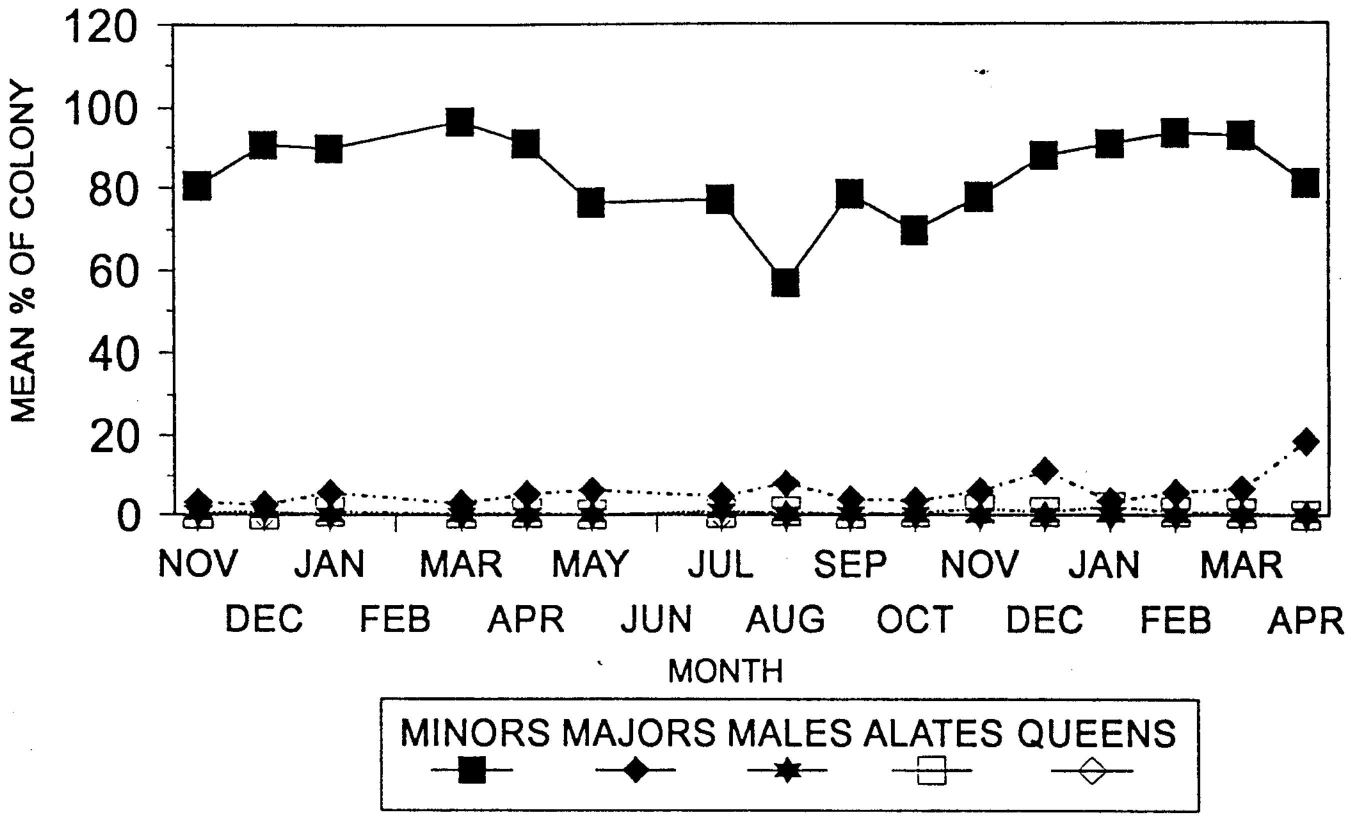
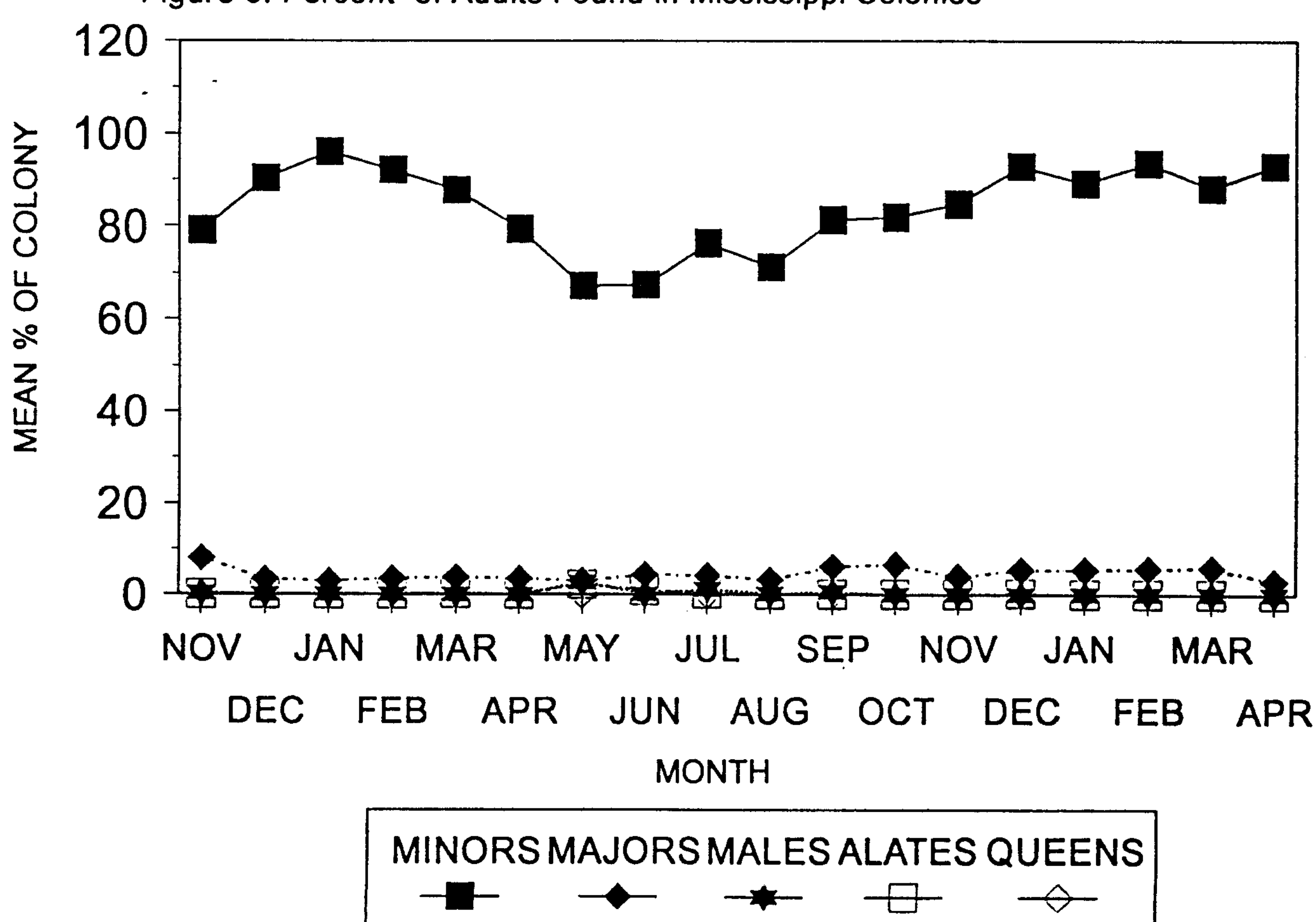


Figure 6. Percent of Adults Found in Mississippi Colonies



1995 IMPORTED FIRE ANT CONFERENCE
SAN ANTONIO, TEXAS

The Impact of Red Imported Fire Ants on Ground-Dwelling Arthropods in a Field-Grown Nursery in Georgia

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INTRODUCTION

The transport of queens and colonies via shipment of sod and nursery stock was probably the greatest factor in the rapid spread of red imported fire ants from 1940 to 1958(Markin 1971). In fact, this artificial movement of queens and colonies may still be the largest contributing factor in their movement into previously uninfested areas. In response to this brisk movement of imported fire ants, a quarantine program was established in 1958 by the USDA (ARS-USDA 1958). Even though imported fire ants have maintained a long relationship with field-grown and container-grown nurseries in the U.S., very little work has been published on the effect of fire ants in these nurseries. Various research has shown imported fire ants to be pestiferous in some agricultural systems yet beneficial in others. Fire ants are known to be nondiscriminatory arthropod feeders, sometimes negatively impacting beneficials in an ecosystem (Lofgren et al. 1975). However, Sterling et al. (1979) reported that red imported fire ants did not influence populations of predators and other insects in a cotton ecosystem. The role of red imported fire ants in the ecosystems within field-grown nurseries is unknown; however, their role could influence the control methods selected by growers to comply with certification requirements. The purpose of this study was to determine the impact that red imported fire ants have on other ground-dwelling arthropods in field-grown nursery operations.

MATERIALS AND METHODS

A 10 ha field belonging to Wight and Bracken Nursery, Cairo, Georgia, was chosen as the site for this year long study. The field was divided into two relatively equal areas that served as the study's plots. The first plot served as the control or fire ant-infested plot. The second plot, the fire ant-free or treatment plot, was treated bimonthly to eliminate the fire ant activity in the plot. A Honda ATV equipped with a Herd GT-77 Seeder® was used to apply Amdro® to one plot at the commencement of the study (January 1993) at the rate of 222 g/ha. Subsequent treatments were made in March, May, July, September, and November around the first of each month. Five subplots were established perpendicularly to the tree rows. The subplots measured 61 m X 61 m and contained four pitfall traps each. Each pitfall trap consisted of 120 ml of ethylene glycol in a 480 ml cup which was buried so that the lip of the cup was flush with the soil surface. The pitfall traps were placed 30 m apart along two 330 m rows in each plot. The selected rows were the fourth row in from each side to reduce any border effect. Pitfall traps were set out one morning during the third week of each month. Twenty-four hours later, the contents in the 40 traps were collected and transported to the laboratory in Tifton. Specimens in each trap were separated into groups according to external morphology and size. The total number of specimens in each group was counted and recorded each month. The specimens were identified to the family, genus, or species level depending on their determined level of importance.

Monthly totals were combined to give a yearly total number of specimens captured for each group in each trap. The traps in each subplot were combined for each treatment to give a total number of specimens per group per plot. Least square means analyses were performed on the plot data for each group. Also, the five plots in each treatment were combined and analyzed by least square means to determine treatment effect.

RESULTS AND DISCUSSION

CONTROL- The multiple treatments of Amdro® did not prevent imported fire ants from entering the treated area. However, there was a significant reduction in the number of fire ants in the treated plot vs. the number in the control plot (df=4,1 f=12.25 p=0.0249). The mean number of imported fire ant foragers captured in the traps was 52.8/trap and 5.1/trap in the control plot and the treated plot, respectively. Ants caught in the traps indicate active colonies were either in the plot or close enough to forage into the plot. It is probable that the fire ants caught in the treated area were foragers from outside the plot.

Imported fire ant activity in the untreated plot peaked from April through July with the month of May providing the greatest number of ants per trap (12.0). A dramatic drop in fire ant numbers after July correlated with extremely dry weather during late summer and fall. Foraging activity increased for a short period following a November rain. The number of ants caught in the treated plot remained fairly constant throughout the year. The highest numbers,0.9 ants per trap, were recorded in July and November.

ARTHROPODS COLLECTED- Representatives of nine orders in the Class Insecta and representatives from three other arthropod classes were captured in the pitfall traps during the year. Approximately 80 species were found in the samples.

Approximately 26 beetle and weevil species were found in the combined plots. This accounted for almost 33% of the total number of species and represented the greatest species diversity of any insect order. Hymenopteran specimens were captured more often than any other order, comprising 35% of the total. Five ant species comprised 33% of the total number of individuals caught throughout the year. In addition to S. invicta comprising 18.1% of the total specimens, another ant species, Dorymyrmex bureni, constituted 10.4% of the total captured specimens. This species comprised 12.5% of the control specimens and 7.8% of the specimens captured in the treated plot. These differences were not significant. Brachymyrmex depilis constituted 3.3% of the total, 4.4% of the control, and 1.9% of the specimens in the treated plot. The difference between the number of specimens collected in the two plots was almost significant (df=4,1 f=5.36 p=0.0816) suggesting a possible effect from applications of Amdro®. The two remaining ant species collected, Cyphomyrmex rimosus and Prenolepsis imparis, were collected in such low numbers as to not warrant statistical analysis.

FIRE ANTS vs. OTHER INSECTS- Nine insect species were found to differ significantly between the treatments. Many species were rare; therefore, their numbers were inadequate to conduct meaningful analyses. Imported fire ants and two other insect species had significantly higher numbers in the control plots than in the treated plots. The other six insect species were found in significantly higher numbers in the treated plots, suggesting an inverse relationship with imported fire ants. Four of the six species are known to be potentially important in nursery operations (Will Hudson, pers. comm.). Labidura riparia, the striped earwig, and one leafhopper species, Exitianus exitiosus, were found in high enough numbers to justify consideration, comprising 18.3% and 2.0%, respectively, of the total number of arthropods collected. The other two species, both Coleopterans, made up 0.45% and 0.22%, respectively, of the total captured population. In the combined plots, Solenopsis invicta and L. riparia constituted the largest percentage number of individual specimen collected, 18.1% and 18.3% respectively. S. invicta made up 29.1% of the specimens collected in the control plots and 4.2% of those collected in the treated plots. Conversely, L. riparia comprised 29.5% of the specimens trapped in the treated plots and 9.4% of those trapped in the control plots. There was a significant difference between the two treatments for L. riparia ($df=4,1$ $f=20.76$ $p=0.0104$).

The effect of L. riparia as a predator in nurseries has not been determined; however, its benefits have been documented in other systems (Tyron 1986, Godfrey et al. 1989). This suggests imported fire ants may have a negative impact on the nursery ecosystem.

Exitianus exitiosus has been documented to cause economic damage in nurseries when found in high numbers (Will Hudson, pers. comm.). Leafhoppers in the subfamily Deltocephalinae are known to be vectors of important agricultural plant pathogens (Buntin 1988). The data from the present study shows an inverse relationship between RIFA and E. exitiosus. Wilson & Oliver (1969) reported leafhoppers to be the fourth most captured prey by the polyphagous fire ants. Morrill (1977) also reported fire ants feeding on various homopterans. It is possible that this leafhopper also succumbs to the predatory habits of RIFA. This effect of imported fire ants on the population of E. exitiosus would be beneficial to the nursery owner/operator.

OTHER PREDATORS- Five predaceous beetle species in the families Carabidae and Ciccindellidae constituted 1.7% of the total number of arthropods collected. Statistical differences between the treatments were not found for any of the representatives of these families. This suggests these beetles were not affected by the presence or absence of imported fire ants. Carabids accounted for 1.1% of the total population while Ciccindellids accounted for 0.52% of all arthropods captured.

Two species in the family Staphylinidae were represented in the collections. The first, a minute Staphylinid was found in equal numbers in the two treatments. However, the second representative, a larger species, was found to differ significantly between the two plots. This species was more abundant in the treated plots than in the control plots, suggesting a negative relationship with imported fire ants.

The major impact recorded in this study was the effect of imported fire ants on the populations of the predaceous striped earwig, L. riparia. However, it is not clear whether this impact causes economic loss or gain to the nursery owner/operator. This is due in part to contradictory reports concerning the effectiveness of L. riparia as a predator.

LITERATURE CITED

Agricultural Research Service, U. S. Department of Agriculture. 1958. Domestic quarantine notices. Subpart-imported fire ant quarantine and regulations.

Buntin, G. D. 1988. Species composition and phenology of leafhoppers and planthoppers in bermudagrass forage. J. Econ. Entomol. 81(1): 201-201.

Buren, W. F. 1983. Artificial faunal replacement for imported fire ant control. Florida Entomol. 66(1): 93-100.

Godfrey, K. E., W. H. Whitcomb, and J. L. Stimac. 1989. Arthropod predators of velvetbean caterpillar, Anticarsia gemmatalis Huber, eggs and larvae. Environ. Entomol. 18(1): 118- 123.

Gross, H. R., Jr. and W. T. Spink. 1969. Responses of striped earwigs following applications of heptachlor and mirex, and predator-prey relationships between imported fire ants and striped earwigs. J. Econ. Entomol. 62: 686-689.

Kowalski, T. 1992. New imported fire ant regulatory treatments. Georgia Green Industry Assoc. August. p. 16.

Lofgren, C. S., W. A. Banks, and B. M. Glancey. 1975. Biology and control of imported fire ants. Annu. Rev. Entomol. 20: 1-30.

Markin, G. P., J. H. Dillier, and S. O. Hill. 1971. Nuptial flight and flight ranges of the imported fire ant, Solenopsis saevissima richteri. J. Ga. Entomol. Soc. 6(3): 145-156.

Morrill, W. L. 1977. Red imported fire ant foraging in a greenhouse. Environ. Entomol. 6:416-418.

Raupp, M. J., C. S. Koehler, and J. A. Davidson. 1992. Advances in implementing integrated pest management for woody landscape plants. Annu. Rev. Entomol. 37: 561-585.

SAS Institute Inc. SAS/STAT User's Guide, Version 6, Fourth Edition, Volume 1, Cary, NC: SAS Institute Inc., 1989. 846 pp.

Shetler, D. J. and P. R. Heller. 1984. Survey of insecticide and miticide usage by 158 nurseries in Pennsylvannia. J. Environ. Hortic. 2: 16-24.

Trager, J. C. 1988. A revision of Conomyrma from the southeastern United States, especially Florida, with keys to the species. Fla. Entomol. 71(1): 11-29.

Tryon, E. H. 1986. The striped earwig, and ant predators of sugarcane woodstock borer, in Florida citrus. Florida Entomol. 69(2): 336-343.

Whitcomb, W. H., H. A. Denmark, A. P. Bhatkar, and G. L. Greene. 1972. Preliminary studies on the ants of Florida soybean fields. Fla. Entomol. 55: 129-142.

Wilson, N. L. and A. D. Oliver. 1969. Food habits of the imported fire ant in pastures and pine forest areas in Southeastern Louisiana. J. Econ. Entomol. 63:1268-1271.

ECOLOGICAL IMPACT OF FIRE ANTS ON THE ARTHROPOD COMMUNITY AND FITNESS OF PLANTS IN THE PRAIRIE OF THE UPPER TEXAS COAST

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Populations of red imported fire ant, Solenopsis invicta, reach densities > 1,000 mounds/ha in coastal prairies of Texas but effects on native flora and fauna are poorly understood. Fire ants are entomophagous (Ricks and Vinson 1970, Green 1967) and negatively impact native ants (Porter and Savignano 1990). We used a two-year experiment to test the prediction that high densities of fire ants would negatively affect herbivorous insects and positively affect annual plants on the upper coastal prairie of Texas.

MATERIALS AND METHODS

The study was conducted during 1992 and 1993 at the University of Houston Coastal Center, La Marque, Texas. The habitat is native coastal prairie which is maintained by periodic mowing. Eight 20 m by 20 m plots were established with 40 m between adjacent plots. Logic® was applied to four plots and to a 20 m buffer around these plots at a rate of 2.2 kg/ha to create plots with low ant density. Control plots were treated with plain corn grits (carrier) at the same rate. Rainfall was measured weekly.

Fire ants were censused in each plot every two weeks using plastic cups baited with dog food. The lids were laid on the ground at randomly chosen bait stations. After a 15-minute period for recruitment, the bottoms were snapped on the lids and the cups were placed in an ice chest and later stored in a freezer until the ants could be counted.

Arthropods were assessed monthly by vacuuming each plot with a modified lawn blower. A pouch made of window screen was taped into the intake tube of the vacuum and lined with a mosquito net bag for each sample. A sample consisted of vacuuming a 0.5 m^2 quadrat for 30-seconds. Six random quadrats were sampled in each plot. The mosquito net bag was everted into a plastic bag and the bags placed in an ice chest and eventually stored in a freezer. The arthropods were sorted from vegetation and then identified to family for herbivorous insects and to order for other groups.

The annual composite, Rudbeckia hirta, was used to test for effects on plant fitness. The coastal prairie contains few annual plants. Most of the prairie is composed of perennial, clonal grasses with a sprinkling of perennial forbs such as *Liatris*. Rudbeckia hirta was selected because it is a non-clonal annual which would have little stored nutrients as in a corm and likely could show the effects of herbivory. Being non-clonal, R. hirta would unequivocally receive nutrients only from one plot. In addition, the selected plant had to be abundant in all plots. R. hirta was the only available plant which fit these requirements. Twenty plants were randomly selected within each plot. After flowering, plants were collected and dried. Root, shoot and inflorescence were individually weighed. Seeds were counted and weighed.

RESULTS

Logic® maintained fire ants on treated plots at densities 20% that of ants on control plots. Fire ant abundance averaged 0 to 85 per bait cup for low-ant plots and 7 to 340 for high-ant plots for those months (May - September) when fire ants attained their highest density. Individual bait cups within high-ant plots could have up to 1200 fire ants.

There were significant differences in abundance of some arthropod groups between low- and high-ant density plots for 1992. Abundance of Aranae, Cercopidae, Delphacidae and Orthoptera increased, whereas abundance of Chrysomellidae decreased. The same trends were seen for 1993, but the results were not statistically significant. Herbivorous insects were analyzed trophically by dividing them into chewer and sucker trophic groups. Chewers included the Orthoptera and Coleoptera, whereas suckers included the Homoptera and Hemiptera. Both trophic groups were significantly more abundant in plots containing high- ant density for 1992. A predator trophic group (Aranae, predatory Coleoptera, and Hemiptera) showed no difference. The trends were similar but not significant for 1993. Acari, Collembola and other families of Homoptera and Hemiptera were not significantly affected by changes in density of fire ants. However, families of Hemiptera tended to be higher in high-ant plots. Of the remaining Homoptera, Aphididae tended to decrease in high-ant plots and Cicadelidae to increase in high-ant plots. (See Table 1)

Annual rainfall during 1992 was 1544 mm, nearly 30% wetter than the 20 yr average at the Coastal Center (1212 mm). Rainfall in 1993 was also high, 1450 mm, but the seasonal distribution was such that spring (March, April, and May) was wetter than normal (121 mm vs. 89 mm, normally) followed by a much drier than usual late summer (July, and August) (13 mm in 1993 vs. 113 mm, 20 yr average). In fact, the month of July had 0.2 mm rainfall (20 yr mean = 121 mm).

Dry mass of *Rudbeckia hirta* shoots, roots, inflorescences and total biomass was significantly higher on high-ant plots in 1992, but was not significant in 1993. Neither seed mass nor seed number was significantly different between high and low ant plots either year. (See Table 2)

DISCUSSION

Clearly, fire ants have had and are having an effect on the prairie ecosystem along the upper Texas coast. Most of the Chrysomellid beetles captured by vacuum were in the subfamily Alticinae. These particular flea beetles are root feeders as larvae which may make them especially easy prey for fire ants. A root feeding habit could explain the possible negative ant effect on Chrysomellids.

The positive effect of fire ant density on spiders may reflect the addition of fire ants to spider diets. In addition, since spiders were among the most abundant arthropods captured, further identification of Aranae may also reveal significant negative effects among particular families and/or genera.

Identification of Homoptera at a finer scale, e.g. genus, also may reveal negative effects of fire ants on some genera and identify genera that are responding positively to high densities of fire ants. Homopterans that increased in the high-ant plots may have been herded and protected by fire ants in exchange for honeydew (Adams 1986). Too few Orthopterans were captured to allow statistical analysis at the family or genus level.

The increase in the sucking trophic group in high ant plots may be driven by the same factors that influenced the Order Homoptera. Too few Hemipterans were vacuumed to show significant results at the family level, so adding herbivorous Hemipterans to the Homopterans would not have changed a generally positive Homopteran response to fire ant density. The chewing trophic group included Orthoptera, which were consistently found in all plots and Coleoptera, mostly flea beetles. Usually, there were more Orthoptera than Chrysomellids which may explain the overall positive effect on the chewing trophic group.

The positive effect of fire ants on annual plants is as predicted. However, the mechanism for this effect is not entirely clear. Root feeding by Alticinae larvae of the Chrysomellidae may have had a significant impact on *Rudbeckia hirta* and fire ant predation on Alticinae larvae may have increased plant biomass in high-ant plots. Nonetheless, other herbivorous insects increased in high-ant plots, but it is true that *Rudbeckia hirta* suffers little damage from these folivorous insects (pers. obs.) perhaps because the leaves are coriaceous and well-armed with stiff hairs. Visual inspection revealed the presence of more Lepidoptera larvae and weevils (Curculionidae: Coleoptera) on *R. hirta* plants in low-ant plots than in high-ant plots, but these observations were not significantly different. In addition, plots within the research area were not equally productive. Even though randomly chosen, high-ant plots tended to cluster in more productive areas (pers. obs.) which would allow *R. hirta* to be more successful in these plots. However, one low-ant plot was also located in a more productive area and *R. hirta* was less successful in this plot than on high-ant plots of approximately the same productivity.

Differences in results between years can be attributed to a wetter than normal 1992 and an unusual pattern of rainfall in 1993. Abundance of all organisms, including fire ants (see figure 1), was much lower in 1993 than 1992. Therefore, the effect of fire ants was actually decreased, probably contributing to the nonsignificant results even though the trends were similar to those in 1992.

LITERATURE CITED

Adams, C.T. 1986. Agricultural and medical impact of the imported fire ants. Pages 48-57 in C.S. Lofgren and R.K. VanderMeer, editors. Fire Ants and Leaf-cutting Ants. Biology and Management. Westview Press, Boulder, Colorado.

Green, H.B. 1967. The imported fire ant in Mississippi. Mississippi Agricultural Experiment Station Bulletin 737. 23pp.

Porter, S.D. and D.A. Savignano. 1990. Invasion of polygyne fire ants decimates native ants and disrupts arthropod community. Ecology 71:2095-2106.

Ricks, B.L. and S.B. Vinson. 1970. Feeding acceptability of certain insects and various water soluble compounds to two varieties of the imported fire ant. Journal of Economic Entomology 63:145-148.

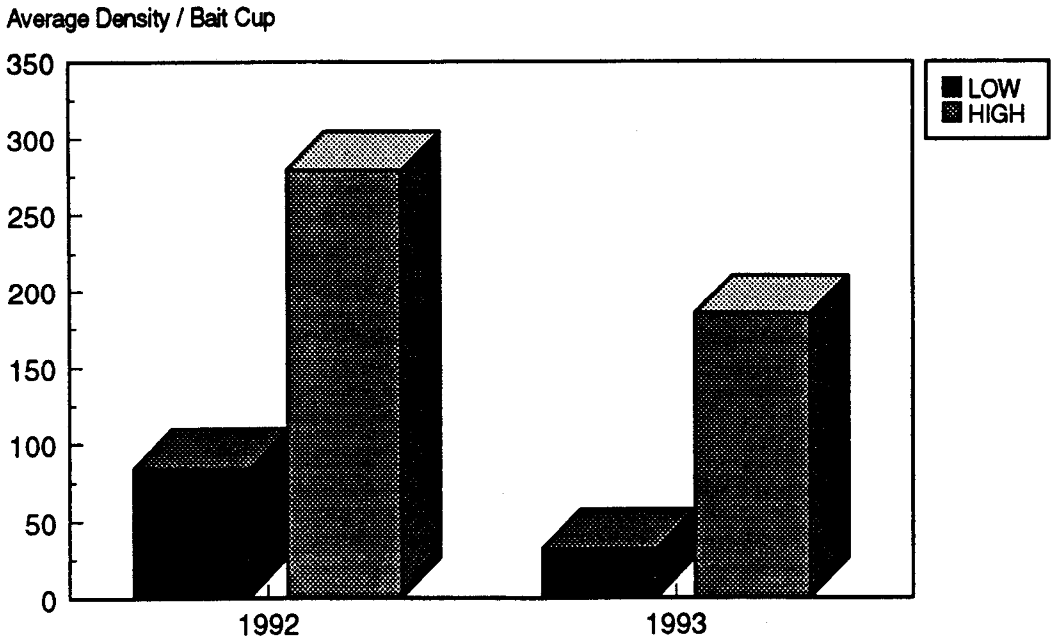
Table 1. Effect of fire ants on arthropods: Mean number arthropods per sample in high- and low-ant plots. *=P<0.05.

	1992			1993		
Arthropod Group	High	Low	P	High	Low	P
Coleoptera						
Chrysomellidae	0.997	1.099	*	1.315	1.697	
Curculionidae	0.735	0.765		0.874	0.872	
Hemiptera						
Tingidae	0.905	0.789		0.967	1.107	
Miridae	1.265	1.149		1.260	1.208	
Reduviidae	0.752	0.736		0.848	0.956	
Lygaeidae	1.260	1.168		1.742	1.638	
Homoptera						
Aphididae	1.302	1.434		1.369	1.485	
Cercopidae	1.224	1.006	*	1.317	1.039	
Cicadelidae	3.056	2.980		2.404	2.488	
Delphacidae	2.403	1.773	*	2.651	1.795	
Orthoptera	1.576	1.103	*	1.681	1.405	
Aranae	3.960	3.236	*	5.490	4.752	
Acari	3.268	3.208		4.052	4.104	
Collembola	1.998	1.712		2.908	2.420	

Table 2. Effect of fire ants on Rudbeckia hirta

Year	Character	Seeds per Plant	Seed Mass / Inflorescence	Root Mass	Shoot Mass	Inflorescence Mass	Total Biomass
1992	Low Ants	984	0.108	0.227	1.258	0.407	1.486
	High Ants	1427	0.099	0.232	1.631	0.493	1.922
	Ant Effect	ns	ns	p<0.05	p<0.05	ns	p<0.05
1993	Low Ants	374	0.071	0.154	0.782	0.299	1.234
	High Ants	361	0.068	0.245	1.02	0.495	1.759
	Ant Effect	ns	ns	ns	ns	ns	ns

Figure 1. Relative fire ant densities



FOOD PREFERENCES OF Solenopsis invicta AMONG SEEDS OF WILDFLOWERS NATIVE TO THE SOUTHEASTERN UNITED STATES.

Timothy C. Lockley

ABSTRACT

One hundred thirty-nine species of wildflower seeds (from 88 genera in 31 families) native to the southeastern United States were presented to field colonies of the red imported fire ant, Solenopsis invicta, from the summer of 1994 through the spring of 1995. Eighteen species were selected during the summer months; 15 species were taken in the fall and nine each during the winter and spring months. Two species (Achillea filipendulina and A. millefolium) were taken in all four seasons. One species (Cichorium intybus) was selected during three of the seasons and two species (Papaver rhoeas and Phacelia campanularia) were fed upon over two seasons. In all. 29.5% of the species tested were selected.

Inhibition of Reproduction by Queen Pheromones in Fire Ants

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Research over the last decade and a half has documented several ways in which fire ant queens use pheromones to inhibit reproduction in the colony. The study of these queen inhibitory pheromones and their effects on reproduction are of interest for 2 reasons. First, on the side of basic research, knowledge of how one or a few individuals are able to control reproduction in the nest is central to our understanding of the evolution and organization of insect societies. Second, on the applied side, detailed understanding of what these pheromones are and how they act may reveal new avenues that could be exploited to control this pest.

Three distinct effects of queen pheromones on fire ant reproduction have been demonstrated: inhibition of the production of new female and male sexuals, inhibition of egg laying by female sexuals and suppression of egg laying by mature queens in polygyne colonies. Current knowledge of these three effects are reviewed, with an emphasis on new findings on inhibition of reproduction by female sexuals. Recent results are presented indicating that the source of the pheromone is the queen poison sac, and that the pheromone acts by triggering **antennal** receptors that then feed back and inhibit juvenile hormone titers.

QUEEN DOMINANCE IN THE POLYGYNOUS ANT, *Solenopsis invicta* BUREN (1): Queen attractiveness to workers as a mechanism of dominance

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Dominance hierarchy is a characteristic phenomenon of co-existing queens in the polygynous ant society. In some ant species, the formation of dominance hierarchies is resolved through aggressive interaction or ritualized domination among dominant and subordinant females (Evesham, 1984; Keller, 1988). Meanwhile, in some other species of ants, multiple queens remain in close contact and tolerate each other (Wilson, 1974; Satoh, 1991; Bouke, 1991). Our studies with queen dominance revealed that a dominance hierarchy is established among queens in a polygynous nest of Solenopsis invicta. The dominant queen was characterized by having a significantly higher attractiveness to workers (HSD method: a = 0.05) than subordinate queens. This is the first evidence that dominance is linked to the queen attractive status to workers.

The evidence of our studies suggested that the dominance was formed in a linearly dominant ranking among the co-existing queens of S. *invicta.* The alpha queen was the top ranking female (dominant queen) in the hierarchy as she attracted most of workers to her nest chamber, while the subordinate queens were about equivalent in social rank as showed by no significant difference (HSD method: a = 0.05) in their attractiveness to workers. After the alpha queen was removed, a beta queen appeared as the most attractive queen. The same thing happened each time following the removal of the moat attractive queen.

The chemical basis for the difference in a queen's attractiveness might be due to the quantitative variation of queen pheromone produced by the queens. Workers may be preferentially attracted to the queen who produced the greatest amount of that pheromone. Our observation that after removal of the dominant queen her empty nest chamber still maintained the highest attractiveness to workers is a evidence that a queen pheromone plays a role in dominance.

Although one most attractive queen always appeared no matter the number of queens or the size of the colonies, we observed that the intensity of the attractive power of a dominant queen decreased as the number of queens and the size of colony increased. Keller and Passera (1989) hypothesized that bleeding of the distinct queen pheromone in polygynous colonies may lead to a less distinct colony odor which might further result in reduced aggression. Our results showed that an increase in the number of queens resulted in a decrease of attractiveness to workers by dominant queen, which may explain the reduction of intercolonial competition. This result also corresponded with the discovery that the fecundity of individual queens was negatively correlated to their number in a polygynous nest of *S. invicta.*

References

Bourke, A. F. G., 1991. Queen behaviour, reproduction and egg-cannibalism in multiple-queen colonies of the ant *Leptothorax acervorum*. Ani. Behav. 42:295-310.

Evesham, E. J. M., 1984. Queen distribution movement and interaction in a semi-natural nest of the ant *Myrmica rubra* L. Ins. Soc. 31:5-19.

Keller, L., 1988. Evolutionary implications of polygyny in the argentine ant, *Iridomyrmex humilis* (Mayr) (Hymenoptera: Formicidae): an experimental study. Anim. Behav. 36:159-165.

Keller, L. and L. Passera, 1989. Influence of the number of queens on nestmate recognition and attractiveness of queens to workers in the Argentine ant, *Iridomyrmex humilis* (Mayr). Anim. Behav. 37:733-740.

Satoh, T. 1991. Behavioral differences of queens in monogynous and polygynous nests of the *Camponotus nawai* complex (Hymenoptera: Formicidae). Ins. Soc. 38:37-44.

Wilson, E. O., 1974. Aversive behavior and competition within colonies of the ant *Leptothorax curvispinosus*. Ann. Entomol. Soc. Am. 67:777-780.

QUEEN DOMINANCE IN THE POLYGYNOUS ANT, *Solenopsis invicta* BUREN (2): The distribution, attractiveness, trophallaxis, and fecundity of queens in laboratory colonies

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There is growing evidence that co-existing queens in a polygynous nest are not all homogeneous. They display variable degrees of ovary development, oviposition rate, weight, selective oophagy, and attractiveness to workers (Wilson, 1974: Evesham, 1984; Brian, 1986, Ross, 1988; Sommeijer and Van Veen, 1990). Our earlier studies on the polygynous ant, Solenopsis invicta, have shown that individual queen attractiveness to workers is unequal. There was always one queen that had the dominance attraction, as she had most of the workers and almost all the brood in her nest chamber. We speak of the dominant queen. In order to further understand the interaction of co-existing queens and the characteristics of a dominant queen, we investigated the distribution, attractiveness, trophallaxis, and fecundity of queens in the *S.* invicta polygynous nest.

A general pattern of queen dominance interaction in S. invicta has been drawn from our studies. The queens of polygynous *S.* invicta showed no evidence of aggressive fighting with each other. The co-existing queens exhibited a peaceful relationship by staying motionless and usually clumping together. The attractiveness of individual queens to workers apparently played a critical role in establishing and maintaining the queen dominance. The higher attractiveness to workers resulted in a dominant queen which had a higher frequency of trophallaxis as she received preferential feeding from the workers (Spearman Rank Correlation: $r = 0.976$, $p = 0.01$). Conversely, the deprivation of food resulted in a complete disappearance of dominance attraction of the dominant queen.

Furthermore, trophic advantage resulted in the reproductive success of the dominant queen, so that she had a higher oviposition rate over a given experimental time period (Spearman Rank Correlation: $r = 0.62$, $p = 0.10$). However, dominance was not associated with the queen weight.

In general, polygynous queens in *S. invicta* are mutually tolerant but reproductively competitive. Attractiveness, trophallaxis, and fecundity are intrinsically linked in queen dominance and are probably mediated by queen pheromone. The knowledge of colony organization, life history, selective advantage, and genetic relatedness of polygynous colonies will enhance our understanding of the formation of dominance hierarchy.

References

Brian, M. V., 1986. The distribution, sociability and fecundity of queens in normal groups of the polygyny ant *Myrmica rubra* L. Ins. Soc. 33:118-131.

Evesham, E. J. M., 1984. Queen distribution movements and interactions in a semi-natural nest of the ant *Myrmica rubra* L. Ins. Soc. 31:5-19.

Ross, K. G., 1988. Differential reproduction in multiple-queen colonies of the fire ant *Solenopsis invicta* (Hymenoptera: Formicidae). Behav. Ecol. Sociobiol. 23:341-355.

Sommeijer, M. J. and J. W. Van Veen, 1990. The polygyny of *Myrmica rubra*: selective oophagy and trophallaxis as mechanisms of reproductive dominance. Entomol. Exp. Appl. 56:229-239.

Wilson, E. O., 1974. Aversive behavior and competition within colonies of the ant *Leptothorax curvispinosus*. Ann. Entomol. Soc. Am. 67:777-780.

Research on the Molecular Biology of Fire Ants

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The tools of molecular biology can play a role in answering many questions related to the fire ant. We have identified two questions that have arisen as a result of previous chemotaxonomy research (Vander Meer and Lofgren 1990). First was the discovery of hybridization between the red and black forms of imported fire ants. The fact that the hybrid is morphologically almost indistinguishable from one of its parents (S. *richteri)* and the hybridization event itself negated the original criteria used to separate the red imported fire ant into the new species, S. *invicta*.. Our results brought into question whether or not the two were indeed different species. Here in the U.S. there are no apparent pre-mating, mating, or post-mating isolation mechanisms. A search in South America for their distinctive chromatotypes revealed that S. *invicta* and S. *richteri* were geographically separated and did not have the opportunity to mate. In the United States this pre-mating isolation mechanism did not exist. However, mating between the two forms may not be symmetrical, leading to incomplete gene flow. Molecular biology offers the tools needed to address this question.

In related work we discovered that the range for S. *invicta* in South America based on chromatotype corresponded well with the range determined by morphological considerations. However, the same was not true for S. *richteri* . The United States chromatotype was found only in a small part of northeastern Argentina (Uruguay was not investigated), but morphologically the range for S. *richteri* was much larger. The non-U.S. chromatotype was dramatically different from the U.S. chromatotype, which is indicative of the presence of cryptic species. Molecular markers could help establish whether or not cryptic species exist.

Mitochondrial DNA (mtDNA) is usually passed on solely through female sexuals, and could provide the most information about gene flow in the fire ant hybrid zone. We initially chose to apply the technique of restriction fragment length polymorphisms (RFLP) to the fire ant problem. This method generates patterns of bands on gel electrophoresis. These patterns can be used to determine maternal lineages and relationships among populations. Usually significant differences exist even between closely related species, making it possible to identify these with a high degree of probability.

The mtDNA of S. *invicta* has been cloned and a restriction map of the mtDNA constructed. We have the capability to sequence the mtDNA genome. We have found mtDNA RFLPs that distinguish between *S. invicta* and S. *richteri* . Preliminary data indicates that symmetrical mating does not occur, thus gene flow is imperfect supporting the designation of *S. invicta* as a separate species. We have not yet addressed the question of cryptic species of *S. richteri* in South America. We anticipate a great deal of spin-off from the molecular biology of fire ants, for example, to define more precisely the fire ant populations here and in South America, and to develop novel next generation control methods.

Literature Cited

Vander Meer, R.K. and C.S. Lofgren. 1990. Chemotaxonomy applied to fire ant systematics in the United States and South America, pp. 75-84. In: Applied Myrrnecology: A World Perspective. R.K. Vander Meer, K. Jaffe, and A. Cedeno (eds), Westview Press, Boulder CO. 741pp.

RESPONSE OF THE RED IMPORTED FIRE ANT (RIFA), *SOLENOPSIS INVICTA* BUREN, TO CURRENT AND CONDUCTIVE MATERIAL OF ACTIVE ELECTRICAL EQUIPMENT

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Red Imported Fire Ant (RIFA) attraction to and aggregation at electrical equipment is induced only when ants can touch both bare contacts of the active electrical circuit. This contact causes current flow through ants' bodies, resulting in peculiar behaviors and often death. These peculiar behaviors, including the release of chemical cues, excite and attract other ants to the site. We negated ant response to a strong electric field of 197 Volts/millimeter by sheathing circuit contacts, thereby preventing complete ant access to active conductive material.

LOCALIZATION OF BIOGENIC FERROMAGNETIC MATERIAL IN THE RED IMPORTED FIRE ANT (RIFA), *SOLENOPSIS INVICTA* BUREN

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Red Imported Fire Ant (RIFA) queens, alates, and major workers were examined for the presence of internal ferromagnetic material. Using an iron-specific staining technique, we located small, diffuse areas of iron-containing tissues in the thoraces of queen and alate ants. These preliminary results are being confirmed with alternative methods for iron localization.

SOUNDS PRODUCED BY IMPORTED FIRE ANTS

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We have confirmed that sound produced by imported fire ants is used for communication. A video was presented showing the connection between gaster flagging and the production of sound. We have recorded a variety of signals produced by the fire ants in situations such as alarm, distress, and while attacking prey. The signals were analyzed using sonograms and other signal-analysis procedures. The frequency range of the signals is principally below about 2 kHz. The sound-pressure level inside a disturbed colony, resulting from the alarm signals of large number of ants, is about 40 dB(A), which is about 3 times more than the sound of a faint whisper. In addition to these signals, sounds due to normal movement within the ant colony can be detected. We have developed an acoustic sensing system to be used with microscopic observation of insect activity.

Materials and Methods

The experiments were conducted during a period of four weeks. The first test was to insert a rod with a Bruel and Kjaer 112-inch microphone into an imported-fire-ant mound in the vicinity of our laboratory at the University of Mississippi. We originally thought that we would record only the activity sounds of the ants i.e. sounds of movement and other activity in the mound, since we had been informed that imported fire ants communicated principally by means of pheromones. Instead we heard a cacophony of sound that was obviously being produced by the fire ants themselves. We were prompted therefore to proceed with further tests n the laboratory.

First we verified that the mandibles of the fire ants had the 4-tooth pattern associated with, ***Solenopsis invicta*** **Buren**. The color of the ants appeared to be more black than red, however. Next, part of the fire-ant mound was removed and put in a plastic container in a sound-proof box which had custom-made acoustic sensors under the container. We then listened to the normal activity sounds of the ants punctuated by short bursts of sound produced by one or two of the ants. We also inserted a caterpillar into the container and recorded the sounds of the ants attacking it. These included prolonged signals generated by one or more of the ants. We recorded some of the individual signals for later analysis.

To determine how the signals were generated, we observed a single ant that had a mandible caught between the container and the lid. It continuously generated signals by gaster flagging. A video established a direct connection between the occurrence of the sound and the gaster flagging movement. This was a distress signal. Other ants came to its aid and eventually succeeded in pulling it free.

Results

The A-weighted sound-pressure level of the sound inside a disturbed imported-fire-ant colony was estimated to be about 40 dB(A), which is 10 dB(A) above a faint whisper. These sounds could not be heard outside the mound because of muffling by the soil. The network of tunnels inside the mound appears to be well-designed to convey air-borne sound to the limits of the colony. How the ants detect air-born sound appears, as yet, unknown.

Preliminary analysis of the individual sounds of the imported fire ants indicted that the frequency content of the sounds was principally below 2 kHz. Sound in this frequency range travels relatively unattenuated in the tunnels in the colony, because the walls of the tunnels are hard compared to the loose soil surrounding them.

Discussion

One question that can asked is whether imported fire ants have a rudimentary language by which they communicate. The different sounds we recorded and the adaptation of the mound to convey air-borne sound indicate that this is a possibility. Such a capability would aid imported fire ants in their highly organized behavior. Another question is whether other species of ants have a similar ability.

Potential Use of *Pseudacteon* Phorid Flies as Fire Ant Biocontrol Agents

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The imported fire ant ***Solenopsis invicta*** is one of the most abundant insect pests in the southeastern United States. With average densities of 1,500-3,500 ants/m^2, these pests are virtually ubiquitous in parks, pastures, yards and cultivated fields. Fire ant densities in the United States are about five times higher than those in South America. Escape from numerous natural enemies left behind in South America is a likely explanation for this difference.

At least 18 species of ***Pseudacteon*** flies have been found attacking fire ants in South America. Each species has a distinctively shaped ovipositor that is presumably used in a lock and key fashion to lay eggs on a particular part of an ant's body. These flies appear to be common and active throughout most of the year, but different species are sometimes more active at different times of the day. Most species are broadly distributed across a wide range of habitats and climates.

The maggots of at least one and probably all ***Pseudacteon*** species develop in the heads of fire ant workers. Larval development takes about 2-3 weeks. Just prior to pupation, the third instar maggot appears to release an enzyme that dissolves the membranes that hold the exoskeleton together. The maggot then proceeds to consume the entire contents of the ant's head, a process that usually results in decapitation of its living host. The headless body is usually left with its legs and sting still twitching. The maggot then pushes the mouth parts aside and pupates within the empty head capsule positioned so that the anterior three segments precisely fill the oral cavity. The remainder of the puparium remains unsclerotized and is protected by the head capsule. The workers carry the head capsule with the puparium outside shortly after the host is killed. Pupal development requires about three weeks.

Fire ant workers are keenly aware of the presence of phorid flies. The presence of a single fly usually stops or greatly reduces the foraging efforts of hundreds of workers in only a minute or two. As soon as a fly appears, many workers will retreat into the exit hole or find cover. Other workers will curl into a stereotypical c-shaped defensive posture that has not been seen except when the ants are under attack by phorid flies. The flies will inhibit fire ant foraging as long as they are present, often for periods of several hours. Several flies are also sufficient to stop nest construction or freeze the activity of entire colonies in laboratory nest trays. The overall impact of these flies on fire ant populations is unknown; however, it is sufficient to have caused the evolution of a number of phorid-specific defense behaviors.

All ***Pseudacteon*** flies are almost certainly parasites of ants. They have never been reported to attack any other kind of organism, and virtually all phylogenetically related phorid genera are also ant parasites. Their elaborate ovipositors and the adaptations of at least one species for pupation in the head capsules of worker ants further supports the conclusion that they are very specialized parasites. The ***Pseudacteon*** species that attack fire ants appear to be specific to fire ants. The host specificity of several parasitic ***Pseudacteon*** flies in South America was tested in the field with 23 species of ants from 13 genera. As expected, these flies were attracted only to ***Solenopsis*** fire ants. Further tests are necessary, but these results strongly suggest that ***Pseudacteon*** flies will not pose an ecological danger, either to other arthropods or to other ant genera if they were introduced as natural biological control agents for imported fire ants in the United States.

In summary, phorid flies in the genus ***Pseudacteon*** are a promising group of biological control agents for fire ants because: 1) they axe specific in their host preferences, 2) they are broadly distributed across time, space, and climate, and 3) their impact on fire ant populations is sufficient to have caused the evolution of several phorid-specific defense behaviors. Successful release of these flies would not eradicate imported fire ants, but it might tilt the ecological balance in favor of our native ants. If this happens, fire ant populations in the United States could be reduced to levels similar to those in South America.

Prevalence of the strepsipteran, *Caenocholax fenyesi*, stylopizing *Solenopsis invicta* colonies in Brazos County, Texas

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ABSTRACT

The prevalence of the strepsipteran, ***Caenocholax fenyesi*** Pierce, which stylopizes ***Solenopsis invicta*** Buren, was examined in Brazos County, Texas. ***Caenocholax fenyesi*** was found to have a sporadic geographical distribution in ***S. invicta*** colonies. Strepsipteran prevalence in stylopized colonies varies up to two percent. We discuss the significance of this prevalence and possible reasons why the prevalence is not larger.

INTRODUCTION

Caenocholax fenyesi Pierce is a strepsipteran parasite that stylopizes the red imported fire ant, ***Solenopsis invicta*** Buren (Kathirithamby and Johnston 1992). ***Caenocholax fenyesi*** was first described by Pierce (1909) from males collected in Cordoba, Mexico, but the host was not determined. Male ***C. fenyesi*** have been collected from several other sites in North America including, Georgia and Arizona (Johnson and Morrison 1979); Alabama (Jones et al. 1980); Louisiana (Khalaf 1969); Florida (Meadows 1967); and the Bahamas (Kathirithamby and Peck 1994). ***Caenocholax fenyesi*** has been discovered in Argentina (Bohart 1941), Panama and Guatemala (Kifune 1979).

Caenocholax fenyesi is a member of the family Myrmecolacidae, which is unique in having its sexes both parasitic and occurring separately in different host species. Thus, the males are in one host species and the female is in a different host species. In this family, all known male hosts are ants while all females are found in orthopteroid hosts. The Strepsiptera are parasitoids that are most commonly host specific or at least restricted to very closely related host species. Mating occurs when the adult male emerges from its host and locates a female, which remains in its host species (adult females are only free living in the family Mengenillidae). Dispersal in the Strepsiptera is by the first instar triungulin larvae. The triungulin leaves the parasitic female via the brood canal and is responsible for finding its host. After successfully finding a host, the triungulin forces itself between sclerites and into the body of its future host. The triungulin then molts and goes through its subsequent larval instars as a maggot-like form. Upon pupation and emergence of the adult male, the host ant dies.

In studying the strepsipteran-fire ant relationship, we are trying to determine the impact that strepsipterans have on fire ant populations. This will allow us to investigate the biological control possibilities afforded by *C. fenyesi*. In this part of our study, we examined the prevalence of stylopization in Brazos County, Texas. Prevalence was examined geographically and within single colonies. We have used this information and other aspects of this relationship to discuss possibilities for biological control.

MATERIALS AND METHODS

Collections of *Solenopsis invicta* colonies were made along a county-wide transect of Brazos County, Texas. The transect was derived by putting a grid over a Brazos County map and collecting as near as possible to the areas where the grid lines intersect. This divided the county into 25 equally separated sites and provided complete coverage of Brazos County. Three fire ant colonies were dug and placed in five gallon buckets at each site, which were then brought to the laboratory.

To separate ants from the soil, colonies were placed under slow dripping water, causing the ants to raft together. Prior to placing the rafted ants in artificial nests for subsequent observation, a random sample of at least 100 ants was removed and placed in 80% EtOH. This random sample was used to determine the prevalence of *C. fenyesi*.

Ants placed in artificial nests were observed for emergence of *C. fenyesi*. *Caenocholax fenyesi* causes a behavioral change the fire ant prior to emergence. Ants with an observed behavior change were placed in covered petri dishes and the strepsipteran was allowed emerge. The emergence of a strepsipteran gave proof that some portion of the ant colony was stylopized.

The prevalence of the strepsipteran within the colonies was quantified using the random sample previously set aside. These ants were cleared in 10 % KOH, at 24° C, for seven to ten days. The cleared ants were then slide mounted and observed using a compound microscope at 100X. The triungulin larvae or exuviae of the triungulin can be seen in stylopized ants. The shed exuviae of the triungulin is never eliminated from the ant. A minimum of 100 ants were examined from each colony. Several sites known to have stylopized colonies were recollected to provide more data to quantify the prevalence of *C. fenyesi* in Brazos County.

RESULTS

Caenocholax fenyesi has a sporadic distribution in Brazos County. Six out of the sixteen transect sites that have been sampled contained stylopized fire ants (Figure 1). The sites containing *C. fenyesi* were randomly distributed in Brazos County. At the transect sites where *C. fenyesi* is found, not all colonies have stylopsized ants.

To date, three sites have been quantitatively measured for percentage of the colony stylopized. The prevalence of stylopization ranges from less than one half percent to two percent (Table 1). Levels of less than one half percent are reported in the table for all colonies that had emergence of strepsipterans in the lab, but had none recorded in examining up to 200 cleared ants.

Table 1. Percentage of *Solenopsis invicta* stylopsized by *Caenocholax fenyesi* at three sites in Brazos County, Texas.

LOCATION	ANTS SAMPLED	STYLOPIZED ANTS	PERCENT STYLOPIZED
Bee Creek Park			
7 X 1993	163	1	0.6
18 X 1993	105	0	<0.5
14 III 1994	200	4	2.0
14 III 1994	200	3	1.5
Research Park			
7 VI 1994	200	2	1.0
7 VI 1994	200	2	1.0
7 VI 1994	200	1	0.5
27 VI 1994	200	2	1.0
Koppe Bridge			
7 VI 1994	200	0	<0.5
29 VII 1994	200	0	<0.5
11 I 1995	200	0	<0.5
31 I 1995	200	4	2.0

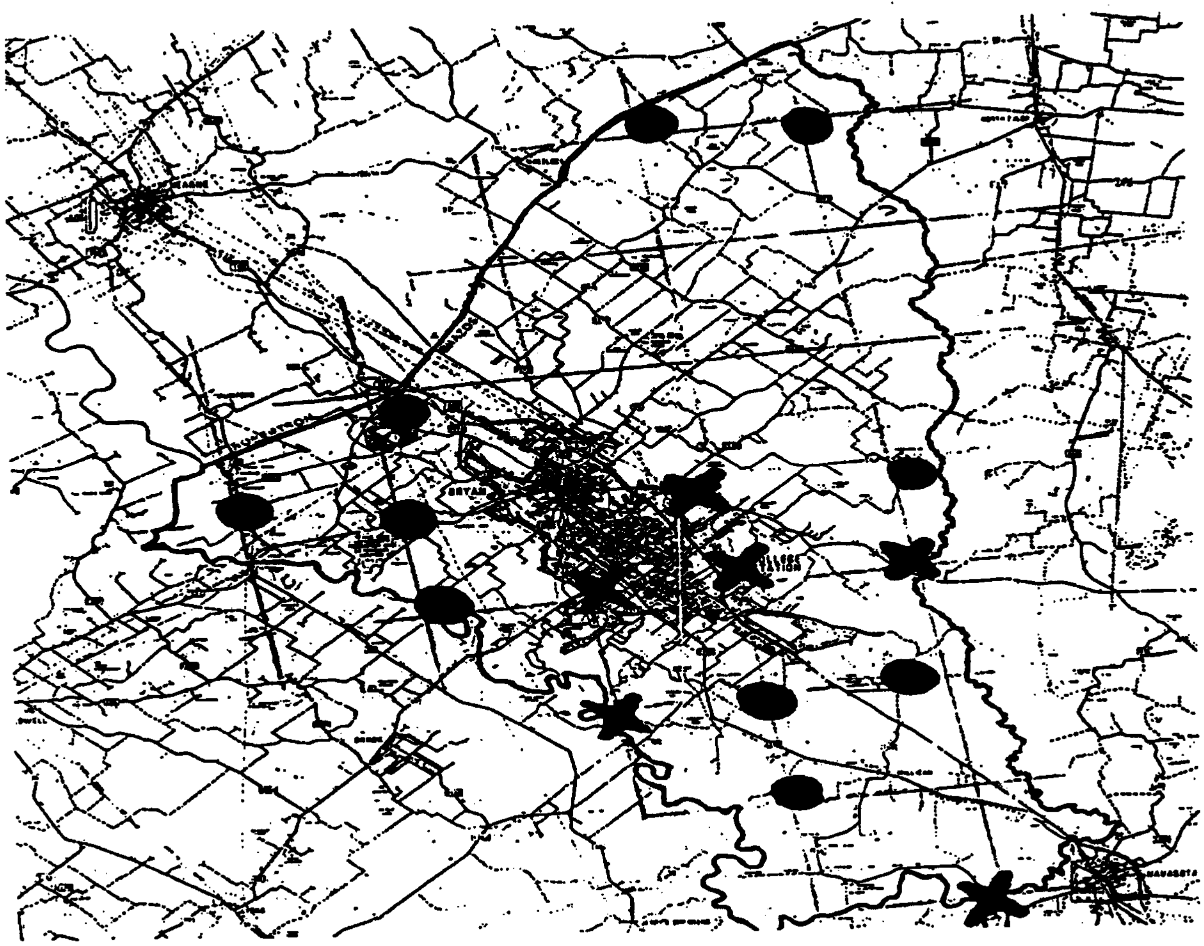

Figure 1. Map of Brazos County showing the distribution of *Solenopsis invicta* colonies stylopized by *Caenocholax fenyesi*. Heavy X's mark sites where *C. fenyesi* is found. Large circles mark locations sampled in which no stylopized ants were found.

DISCUSSION

The discovery of *Caenocholax fenyesi* parasitizing *Solenopsis invicta* (Kathirithamby and Johnston 1992) provides a possible biological control agent for the imported fire ant. Our study shows that the level of stylopization is small in *Solenopsis invicta* populations in Brazos County; however, this does not suggest that higher prevalence of stylopization might not be possible.

There are several reasons that the level of stylopization may be low. The first possibility is that the prevalence of strepsipterans in fire ants is limited by the number of females or female hosts available. Another possibility is that male *C. fenyesi* have recently undergone host switching and are not well adapted to the biology of *S. invicta*. Finally, *C. fenyesi* may be a recent introduction to the area studied and the parasitoid is not as widespread or as prevalent as it may become.

The female of *C. fenyesi* has not been discovered. Since all other species in this family have males in ant hosts and females in orthopteroid hosts, it is presumed that the female of *C. fenyesi* is also in an orthopteroid host. This relationship is likely but not certain and after an exhaustive attempt to find the female, it is still unknown. If the female host is present in very small numbers, which is suggested by our efforts, this may be the limiting factor in the prevalence of stylopization of *S. invicta*. Finding the female *C. fenyesi* and its host will be crucial to answering this question. When the female is known there may be a way to influence its numbers, or its host's numbers, and substantially increase the stylopization of *S. invicta*.

There are several factors that make it likely that *C. fenyesi* has changed hosts to *S. invicta* in Brazos County. *Caenocholax fenyesi* was first described by Pierce (1909) from samples collected in Cordoba, Veracruz, Mexico. *Solenopsis invicta* does not occur in or near this region of Mexico and *C. fenyesi* is a poor flier that lives only a few hours in the adult stage. It is, therefore, very unlikely that *S. invicta* was the host of these specimens. A more likely original host is *Solenopsis geminata* (Fabricius), which is found in this region of Mexico as well as the southeastern United States. *Solenopsis geminata* is currently being competitively displaced by *S. invicta* in much of its range in the United States (Hung and Vinson 1978). In Brazos County, *S. geminata* has not been found for several years. The idea that *C. fenyesi* has been introduced to this area with *S. invicta* is unlikely because of the probable dual host of the sexes of *C. fenyesi*. An introduction would require nearly simultaneous introductions of not only the ant host for the male, but a host for the female that has spread along with the spread of the fire ant. It is much more likely that *C. fenyesi* has crossed over from one member of the genus *Solenopsis* to another. We are currently examining remaining populations of *S. geminata* in Texas to support this theory. If *C. fenyesi* has indeed recently crossed-over to a new host, it might not be well adapted to its new host, *S. invicta*, thus limiting the level of successful stylopization.

REFERENCES CITED

Bohart, R. M. 1941. Revision of the Strepsiptera with special reference to the species of North America. Univ. Calif. Pub. Entomol., 7(6): 91-160.

Hung, A. C. F. and S. B. Vinson. 1978. Factors affecting the distribution of fire ants in Texas (Myrmicinae: Formicidae). Southwest. Nat., 23(2): 205-214.

Johnson, V. and W. P. Morrison. 1979. New North American distribution records for four species of Strepsiptera. Ent. News, 90(5): 251-255.

Jones, D., M. L. Williams, and G. Jones. 1980. Records of Strepsiptera in Alabama. J. Ga. Entomol. Soc., 15: 404-406.

Kathirithamby, J. and J. S. Johnston. 1992. Stylopization of *Solenopsis invicta* (Hymenoptera: Formicidae) by *Caenocholax fenyesi* (Strepsiptera: Myrmecolacidae) in Texas. Ann. Entomol. Soc. Am., 85(3): 293-297.

Kathirithamby, J. and S. B. Peck. 1994. Strepsiptera of South Florida and the Bahamas with the description of a new genus and species of Corioxenidae. Can. Entomol., 126: 125-134.

Khalaf, K. T. 1969. Strepsiptera from the Mississippi coast. Fla. Entomol., 52: 53.

Kifune, T. 1979. New Localities of *Caenocholax fenyesi* Pierce, 1901 (Strepsiptera: Myrmecolacidae). Kontyu, 47: 411.

Meadows, K. E. 1967. Distribution of two Strepsiptera in Florida: 1960-1962. Fla. Entomol., 50(2): 137-138.

Pierce, W. D. 1909. A monographic revision of the twisted winged insects comprising the order Strepsiptera Kirby. U. S. Nat. Mus. Bull., 66: 1-232.

Ice-Nucleating Active Bacteria as a Winter Management Tactic for the Red Imported Fire Ant

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Summary

Overwintering strategies are important in the survival of insects, and one such strategy involves the regulation of temperatures at which they freeze. Although all insects exhibit some degree of cold tolerance, they can generally be classified as either freeze tolerant or intolerant. A freeze-tolerant species can survive temperatures that cause extracellular ice formation, whereas a freeze-intolerant species can survive only at temperatures above crystallization (Bale, 1987; Salt,1961). The moment at which crystallization occurs is referred to as the supercooling point and is readily measured by the release of latent heat. Supercooling abilities differ among species and are somewhat affected by physiology, behavior, and the environment (Salt, 1961).

Many freeze-intolerant insects seasonally depress their supercooling points, thereby increasing their cold-hardiness in preparation for winter (Lee et al., 1994). Numerous studies on overwintering insects indicate that cold acclimation for weeks or months increases cold tolerance (Chen and Walker, 1994). Exposure to low temperatures, particularly in the range of 0° to 5° C, triggers the accumulation of cryoprotectants and enhances cold-hardiness (Baust and Lee, 1981).

We studied the influence of cold acclimation on the supercooling ability of <u>Solenopsis invicta</u> Buren. Colonies were consecutively exposed for seven days to decreasing temperatures of 10°, 6°, and 0" C (treatments). At the end of each seven-day period, whole body supercooling points of randomly selected worker ants from each colony were determined with thermocouple probes. In

addition, head capsule widths and whole body weights were measured. Analysis of variance indicated a significant difference among supercooling points and acclimation temperatures ($\underline{P}<0.05$). Individual ants from colonies exposed for one week at 0° C exhibited lower supercooling points compared to individuals from the same colonies previously exposed for one week to 10° C. Also, a significant negative relationship was shown between whole body weights and supercooling points ($\underline{P}<0.05$), indicating that supercooling ability is, in part, a function of size. Therefore, historical temperatures can have an impact on overwintering ability of colonies through the process of acclimation.

In the 1970's, ice-nucleating active bacteria, a new category of biological ice-nucleators, were discovered among epiphytic bacteria living on the surface of plants (Vali, et al., 1976; Schell, 1976). These ice-nucleating bacteria have the capacity to catalyze ice formation at -1° to -2° C (Lee, 1991) and are thus capable of freezing plant tissues at temperatures higher than normal (Lindow, 1987; Warren, 1987). Recently, ice-nucleating active bacteria have been proposed as biological control agents of insects by reducing their supercooling capability (Strong-Gunderson, et al., 1994).

Therefore, we studied the effects of topical mist application of the ice-nucleating bacteria <u>Pseudomonas syringae</u> (ATCC 39254) on the supercooling ability of workers of the red imported fire ant A mixture of two-day growth of <u>P</u>. <u>syringae</u> in nutrient broth, Tween 80, and vegetable oil (treatment A) was topically applied to workers, and whole body supercooling points, head capsule widths, and whole body weights were measured. One control (treatment C) consisted of a mixture of nutrient broth, Tween 80, and vegetable oil, and a second control (treatment B) consisted of <u>Escherichia coli</u> grown in nutrient broth, Tween 80, and vegetable oil. Treatment C was used as a control because it contained live bacteria (<u>E</u>. <u>coli</u>) as did treatment A (<u>P</u>. <u>syringae</u>). Our results show that treatment A significantly increased the freezing point of the red imported fire ant, thus decreasing its supercooling ability (ANOVA; $\underline{P}<0.05$). Both control treatments had no significant effect on supercooling points.

These results support our theory of ice-nucleating active bacteria as a winter management tactic for the red imported fire ant. Although our results are promising, further investigation of these bacteria under field conditions for long-term persistence and efficacy must be examined.

References Cited

Baust, J. G. and R. E. Lee. 1981. Divergent mechanisms of frost hardiness in two populations of gall fly, Eurosta solidaginis. J. Insect Physio. 27: 485-490.

Chen, C. and V. K. Walker. 1994. Cold-shock and chilling tolerance in Drosophilia. J. Insect Physiol. 40: 661-669.

Lee, R. E., J. P. Costanzo, P. E. Kaufman, M. R. Lee, and J. A. Wyman. 1994. Ice-nucleating active bacteria reduce the cold hardiness of the freeze-intolerant Colorado potato beetle (Coleoptera: Chrysomelidae). J. Econ. Entomol. 87: 377-381.

Lee, R. E. 1991. Principles of insect low temperature tolerance. In Insects at Low Temperature (Eds. Lee, R. E. and D. L. Denlinger). pp. 17-46. Chapman and Hall, New York.

Schnell, R. C. 1976. Bacteria acting as ice nucleants at temperatures approaching -1° C. Bull. of Amer. Meteorol. Soc. 57: 1356-1357.

Strong-Gunderson, J. M., R. E. Lee, Jr., and M. R. Lee. 1994. Ice-nucleating active bacteria increase insect mortality at high subzero temperatures. Cryo-Letters. 15: 385-392.

Vali, G., R. W. Fresh, E. L. Galyan, L. R. Maki, and R. C. Schnell. 1976. Biogenic ice nuclei. Part II. Bacterial sources. J. Atmos Sci. 33: 1565-1570.

ALGINATE FORMULATIONS OF BEAUVERIA BASSIANA

Summary

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Problems associated with the formulation and application of living microbial organisms have limited or even rendered ineffectual their use for biological control of insect pests. Sodium alginate formulations of living biological control agents have reduced or eliminated many of these problems. Alginate is a non-polluting, naturally occurring, gel-forming gum that forms a matrix with living organisms in the form of a small pellet. Pellets enhance living organism's survival which translates into greater shelf-life and increased stability in the field. Formulation with alginate also allows addition of ingredients that improve efficacy of biological control agents. Alginated biological control agents have successfully controlled many insect pests, but has not been tested against the red imported fire ant (RIFA).

To test the ability of alginate pellets to cause mortality in RIFA, pellets consisting of *Beauveria bassiana*, rice powder, glucose, and diatomaceous earth were produced. Pellets were soaked in an aqueous polyethylene glycol solution (PEG), an osmotic regulator shown to increase the rate of sporulation of fungi (Knudsen et al. 1991). Two experiments tested the ability of the pellets to cause mortality of RIFAs. The first experiment consisted of individual petri dishes lined with a single sheet of water-moistened filter paper. Ten worker ants, two grams of soil, and 0.25 gram of pellets were added to each dish. Two control treatments were prepared: (a) Pellets produced exactly as were fungal pellets but containing shredded filter paper instead of fungal mycelia. (b) No pellets. This experiment demonstrated that the alginated pellets containing B. *bassiana* caused significantly greater mortality than did either of the control treatments.

The second experiment tested alginate pellets in larger containers with more ants and more soil. Ten-gallon plastic tubs lined with Fluon to prevent ant escape were used. Mound soil, (17 kg), approximately 2,000 worker ants and two queens, and 7 g of pellets were added to each experimental unit. Control treatments were identical to those used in the first experiment. Fungal and control treatments were assigned randomly to each experimental unit. Ants were fed laboratory-reared

cockroaches three times a week and had continuous access to sugar water. Water was added to soil at regular intervals to maintain moisture. Ten days after the experiment was begun, bone-piles of dead ants were removed from each colony and counted. Analysis of variance showed that bone-piles from the fungal treatments contained significantly more dead ants than did the controls. In addition 20% of the dead ants removed from the fungal treatments exhibited fungal growth when plated on potato dextrose agar. Three weeks after the experiment was begun, ants were floated from each container, and the survivors were counted. Analysis of variance showed that the fungal treatments contained significantly fewer survivors than did the controls.

The results of these studies suggest that alginated *Beauveria bassiana* can cause significant mortality when applied to RIFA colonies. Future studies will test the effect of a greater quantity of pellets in large populations of RIFAs.

Reference Cited

Knudsen, G. R., D. J. Eschen, L. M. Dandurand, and Z. G. Wang. 1991. Method to enhance growth and sporulation of pelletized biocontrol fungi: Applied and Environmental Microbiology. 57: (2864-2867).

IFA ELECTRONIC BULLETIN BOARD SYSTEM
SHOULD WE OR SHOULDN'T WE?

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Introduction

The idea was suggested that the imported fire ant (IFA) community needed a way to disseminate a variety of information to all interested members in a timely and efficient manner. Like many special interest groups, ours consists of people employed by many different organizations and companies (federal, state, academic, private industry, nursery industry), and with many different areas of interests (basic biology, genetics. chemical control, biocontrol, quarantine). IFA, like all pests, generates a great deal of information in a variety of forms; scientific data, trade information, quarantine regulations. In this age of information and technology, making information available to the masses and allowing the customer to access what is of interest to him/her is, we believe, an avenue the IFA community may want to consider.

Electronic bulletin board systems (BBS) are a fast growing telecommunications method of exchanging information, ideas, files and shareware software. The majority of these BBSs are personal systems which are used by hobbyists and special interest groups. Many businesses are also using BBSs for customer support services, mail order services, etc.

Why should the IFA community consider using a BBS?

In general, a BBS would provide a forum for the exchange of ideas and information. For example, someone with a problem rearing IFA in the laboratory could post a question concerning diet or environment on the board. Hopefully, he/she will get several messages in return with solutions and/or suggestions. Other areas of information exchange might include the IFA Directory that our laboratory puts out in paper form every year. If it were on a BBS, the directory could be updated as needed and everyone would have access to the new information as soon as it changed. Sanford Porter and Dan Wojcik have an excellent IFA bibliography that would be a wonderful addition to an IFA BBS. In the last few years, the Federal IFA Quarantine has changed many times with deletions and additions to its limited arsenal of chemicals approved for use with nursery stock. Again, updated information on the quarantine made available to everyone concerned in a timely manner is critical. General interest news could also be posted on the BBS; journal articles or citations, newspaper articles, television/news shows, etc. And, of course, users can send and receive semi-private messages to or from other users (the messages may be read by the systems operator - to be discussed later).

What would we need to start a BBS?

A BBS is a fairly easy system to go online with. There are hundreds of BBS software packages available. Some are available as shareware - you can test it out before you decide whether its the one you want, then you pay a registration fee. Others, you buy the package up front. Whichever way you go, the cost is between $70.00 and $250.00. This software is only needed for the computer which will contain and run the BBS. Users only need a communications software program and a modem: i.e. Xtalk, ProComm, SmartComm, or others.

The computer needed to run the BBS would have to be a 386 or higher, with 512K to 4MB RAM, and 15MB hard drive space. All of these criteria depend on the software chosen to run the system. It also needs DOS 3.3 or higher and at least one serial port modem. One modem, i.e. one phone line coming in and therefore only one caller at a time using the system, is probably sufficient for beginning this BBS. More lines and modems could be added later if necessary (again dependent on the software used).

How would we go about setting up a BBS and going online?

The first thing we need is a volunteer to act as the systems operator (SYSOP). This person would choose the software to be used, set up the BBS, distribute the phone number to all interested parties, and maintain and monitor the BBS. This last point of maintaining and monitoring would require some time, probably 2-5 hours per week after the system is up and running smoothly. And, of course, we would need a dedicated computer and phone line to run the BBS which would be online 24 hours a day, 7 days a week. Hopefully, the SYSOP could provide both the computer and the software. Depending on budget and the availability of a computer, our laboratory may volunteer for the SYSOP job. However, if anyone has previous experience in the area and would like to volunteer, please do!!

Discussion

Before the BBS goes online, the SYSOP would need more suggestions and ideas for "conference areas"; what the BBS should contain and make accessible to others. Also, the only costs to the users would be the cost of the telephone call to the BBS.

Now the only question is --- SHOULD WE OR SHOULDN'T WE?

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The impact of red imported fire ants northern bobwhite quail chicks.

Abstract: Our earlier analysis of long term data sets and field experiments suggested that red imported fire ants (RIFA; **Solenopsis invicta)** negatively impact northern bobwhite quail **(Colinus virginianus)** populations. Also in our earlier work, we proposed that RIFA could be impacting bobwhite populations either directly by causing mortality of adult or young quail or indirectly through changing insect populations that are important sources of food for quail. We investigated the impact of direct exposure to RIFA by working with young quail chicks in a laboratory. We examined the effect of exposure to 2 different numbers of RIFA for 2 different lengths of time on body mass and survival of captive, 4-day old quail chicks. Compared to control chicks, survival of quail chicks was lower with exposure to as few as 50 RIFA for 60 sec. or 200 RIFA for 15 sec. Additionally, Body mass was lower in chicks exposed to 200 RIFA for 60 sec. Our laboratory results support our earlier proposal that quail populations could be negatively impacted by direct exposure to RIFA.

SMALL MAMMAL CAPTURES AS INFLUENCED BY SOLENOPSIS INVICTA MOUND DENSITIES

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Mound densities of S. invicta and small mammals were correlated along an 83-km transect representing a gradient of S. invicta densities in eastern Texas during June (1990) and July (1991). Six species of small mammals (S. hispidus, B. taylori, Rattus rattus, Peromyscus spp., Reithrodontomys spp., and Microtus pinetorium) were captured along the transect. Abundance of S. hispidus was not correlated significantly ($P > 0.05$) with the number of S. invicta mounds, whereas total abundance of the other species, grouped together, was significantly ($P < 0.001$) negatively correlated with number of mounds.

Red imported fire ants (Solenopsis invicta) have been shown to alter habitat use and to reduce the carrying capacity of the habitat for some small mammal species (Killion, 1992; Smith et al., 1990; Stoker, 1992). There have been numerous reports concerning the potential impact of S. invicta on mammals and birds (e.g. see Ashdown, 1969; Emlen, 1938; Hill, 1972; Wilson and Silvy, 1988). However, the majority of these observations were collected during studies that were not designed to test the hypothesis that S. invicta has a detrimental impact on vertebrates. In this study, small mammals were trapped along a 83-km transect containing a gradient of S. invicta mound densities ranging from multiple queen colonies to an absence of reported S. invicta infestation. Trapping success rates as a function of S. invicta mound densities were analyzed to test the hypothesis that as the density of S. invicta mounds increases, the abundance of small mammals decreases.

Materials and Methods

Study Area. The transect was defined along the Saint Louis Southwestern Railroad right-of-way through Smith, Upshur, Camp, and Titus counties in northeastern Texas.

Information on the type of S. invicta infestation in each county was determined using a map of S. invicta distribution in Texas (Porter et al., 1991). The transect spanned two diverse ecological regions — Post Oak Savanna and Pineywoods. Smith and Camp counties are of mixed ecological types, with the eastern one-half of each county classified as Pineywoods and the western half as Post Oak Savanna. Upshur is located solely within the Pineywoods region while the portion of Titus county through which the transect was established is Post Oak Savanna (Gould, 1975). Vegetation within this frequently disturbed right-of-way was dominated by annual grasses and herbaceous dicots although there was high variation in the ratio of bare ground to plant coverage.

Small mammal sampling.— Fifteen small mammal trap lines, each with ten Sherman live traps spaced at 10m intervals (total n = 150), were established at equidistant intervals along the transect route. The number of sampling stations was calculated to allow the entire transect to be run before 11:30 A.M. to prevent heat-related trap mortality. The transect was sampled five consecutive days (Otis et al., 1978) during late June, 1990 and again during the first week of July, 1991. All traps were placed within 20m of, and parallel to, the railroad tracks. The exact placement distance of the traps from the railroad tracks varied due to differences in vegetation between the sampling stations. The first trap at each sampling station was located in the most dense area of vegetation cover between the railroad tracks and the predefined 20m limit. A small amount of Diazanon™ was applied to the ground directly under each trap to reduce mortality from S. invicta (Grant, 1982).

Traps were baited at dusk on the first night of the sampling period and bait was added thereafter only as needed. Traps were left open continuously during each sampling period and were checked once daily. On the final day of each sampling period the traps were removed after being checked. Newly captured rodents were marked by toe-clipping to assess recaptures. Data recorded for each captured rodent included capture location (trap line number and trap), recapture status (recapture or new individual), species, sex, and age (adult or juvenile).

Vegetation sampling.— Vegetation at each trap line was assessed using a 30m line transect that paralleled placement of the Sherman traps. Ground cover was recorded at 1dm intervals and categorized by class (grass, forb [herbaceous dicots], woody, litter [leaf litter, detritus], or bare ground) and frequency of occurrence. The mean height of vegetation along each transect also was recorded.

Ant sampling.— Estimates of S. invicta mound (colony) densities were based on information obtained from mound mapping at each trap line as per Porter et al. (1991). Mound densities (mounds/m^2) were calculated from three 30m transects sampled at each trap line as per Porter et al. (1991). Linear regression of mounds/m^2 on total number of small mammals captured at each sampling station were calculated to test the hypothesis that as the density of S. invicta increases, the number of small mammals captured decreases. Pearson correlations were utilized to examine relationships between vegetation cover class (frequency of occurrence), mounds/m^2, and total small mammal captures.

Results

In 1990, 41 total captures were made of three species: Sigmodon hispidus, Rattus rattus, and Mus musculus. Recaptures were frequent, with fewer than 30% of animals captured after the first day being non-marked animals. In 1991, the number of animals increased, with 82 total captures being made comprising five species: S. hispidus, Peromyscus spp., R. rattus, M. musculus and Microtus pinetorum. The number of recaptures during the 1991 sampling was similar to 1990, with 66% of animals captured after the first night being recaptures. Total captures per trap line ranged from zero to 13.

Vegetation class and height were not correlated significantly with either the total number of small mammals captured or mounds/m^2. Correlation coefficients (r) ranged from -0.594 to 0.336.

Mound densities varied considerably along the established transect, ranging from zero to 0.324 mounds/m^2. Mean mound density for the transect was 0.102 in 1991, down slightly from the 0.119 mounds/m^2 recorded in 1990. Clearly, the density of S. invicta mounds decreased as one approached the northern end of the transect (Fig. 1).

In light of findings regarding potential S. hispidus "resistance" to impacts by Solenopsis invicta (D. Ferris, 1994; K. Ferris 1994), two groups of regression analyses were conducted -- one using only S. hispidus capture data and one incorporating data from all species except S. hispidus. Regression analysis using number of mounds/m^2 as a predictor of the total number of S. hispidus captured indicated no significant relationship (1990: $R^2 = 19.7$, $P \leq 0.098$; 1991: $R^2 = 0.0$, $P \leq 0.988$; Pooled: $R^2 = 3.7$, $P \leq 0.310$). Interestingly, the S. hispidus exclusive regressions were significant (1990: $R^2 = 39.4$, $P \leq 0.012$; 1991: $R^2 = 38.9$, $P \leq 0.013$; Pooled: $R^2 = 30.7$, $P \leq 0.001$). The relationships between total number of animals captured and number of mounds/m^2 are illustrated in Figure 1.

Discussion

While it seems reasonable that S. invicta might negatively impact native (and introduced) small mammals, the ecological mechanism and ultimate outcome of the impacts are unclear. The results of this study show a significant inverse relationship between the total number of small mammals captured (exclusive of S. hispidus) and the number of S. invicta mounds/m^2. Captures of S. hispidus captures seem to be unrelated to the density of S. invicta mounds.

It has been suggested that habitat quality, in terms of resource availability and abundance, may play an important role in determining the severity of small mammal - S. invicta interactions. The trap lines followed the right-of-way of a rail line, and traps were placed near or in this right-of-way. The habitat, to human observers, seemed to be at best marginal. Under these conditions of potentially limited resources, one might expect interspecific competition from S.invicta to exert its maximum impact on small mammal populations, a hypothesis supported (for some species) by the results of this study.

The results of this study are consistent with the hypothesis that S. invicta impact small mammal habitat utilization (exclusive of S. hispidus), although sample sizes were somewhat limited with respect to non-S. hispidus species. Habitat utilization by S. hispidus is not impacted by the presence of S. invicta. However, in the areas infested by S. invicta, disruption-sensitive species may have been displaced prior to the onset of this study, leaving only the more "resistant" species. Thus, species captured may not represent species most acutely impacted by fire ants.

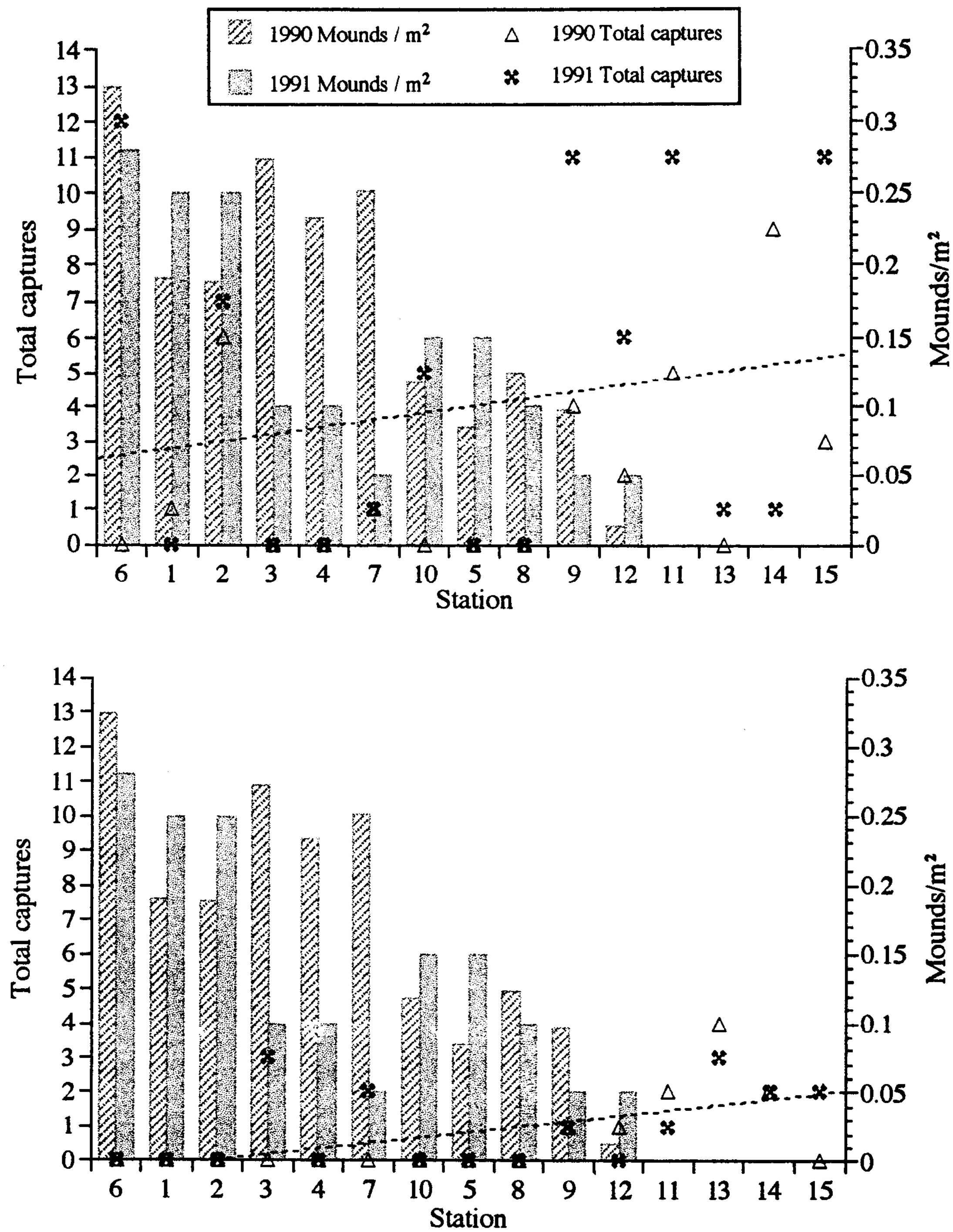

Fig. 1.--Total captures from 1990 and 1991 ranked by decreasing mean number of mounds/m^2. Top graph includes only Sigmodon hispidus captures, bottom graph represents total captures for species other than S. hispidus. Dotted lines represent best fit linear regressions.

LITERATURE CITED

Ashdown, P. 1969. For the defense: Florida conservationist speaks out in favor of fire ant control. Agricultural Chemicals, 24:10-12.

Emlen, J. T. 1938. Fire ants attacking California quail chicks. Condor, 40:85-86.

Ferris, D. K. 1994. Impact of Solenopsis invicta on small mammal habitat utilization and abundance. Ph.D. Dissertation, Texas A&M University, College Station, Texas. 113 pp.

Ferris, K. P. 1994. Experimental analysis of the impact of the red imported fire ant (Solenopsis invicta) on nestling success in simulated nests of hispid cotton rats (Sigmodon hispidus). M.S. Thesis, Texas A&M University, College Station, Texas. 64 pp.

Gould, F. W. 1975. Texas Plants -- A checklist and ecological summary. Texas Agricultural Experiment Station Miscellaneous Publication 585/revised, College Station, Texas.

Grant, W. E. 1982. Small mammals in shortgrass prairies. Pages 331-337 in D. E. Davis, ed. CRC Handbook of Census Methods for Terrestrial Vertebrates. CRC Press, Boca Raton, Florida, 397 pp.

Hill, E. P. 1972. The cottontail rabbit in Alabama. Bulletin 440. Agricultural Experiment Station, Auburn University, Auburn, Alabama.

Killion, M. J. 1992. Small mammal response to red imported fire ant removal in a grassland community. M.S. Thesis, Texas A&M University, College Station, Texas. 64 pp.

Otis, D. L., K. P. Burnham, G. C. White, and D. R. Anderson. 1978. Statistical inference from capture data on closed animal populations. Wildlife Monographs, 62:1-135.

Porter, S. D., A. Bhatkar, R. Mulder, S. B. Vinson, and D. J. Clair. 1991. Distribution and density of polygyne fire ants (Hymenoptera: Formicidae) in Texas. Economic Entomology, 84(3):867-874.

Smith, Tracy S., S. A. Smith, and D. J. Schmidly. 1990. Impact of fire ant (Solenopsis

EFFECT OF RED IMPORTED FIRE ANTS ON WILDLIFE (RODENT) POPULATIONS LAKE CONROE DAM, MONTGOMERY COUNTY, 1994: FIRE ANT MOUND MONITORING AND SUPPRESSION PROGRAM

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Initial results of a two-year project to document the impact of the red imported fire ant, ***Solenopsis invicta*** **Buren,** on wildlife populations are reported. Large plots were established and maintained in which fire ants were suppressed using a biannual application of Amdro® Insecticide Bait (hydramethylnon). This product was selected because of its rapid reduction of fire ant numbers (80 percent in 3 to 5 weeks) and minimal effects on ants outside treated plots. Results from rodent trapping efforts in these plots are to be compared to those from untreated plots. The value of conducting long-term research using this plot design and potential methods of optimizing a sequential bait treatment program using a theoretical re-treatment threshold are discussed.

Materials and Methods

Ten plots, 620 to 656 ft. long and 240 ft. wide (approximately 3.47 acres) were established. On 24 May, 1994, alternating plots were treated with a broadcast application of Amdro® Insecticidal Bait (Lot #310401E, 0.73% hydramethylnon), using 5.2 lbs. (1.5 lbs./acre) of the bait formulation per plot using a tractor mounted Herd Model GT-77 spreader. Each treatment plot was covered with eight 30 ft. wide swaths. The weather was partly cloudy and temperature was 80-87°F. Grass was dry during treatment (10:15 am to 12:15 pm).

Fire ants were monitored by counting the number of active mounds along three 30 by 160 ft. (0.11 acre) transects, starting and ending 40 ft. from the edge of each plot, using the minimal disturbance method, May 25, 1994. Treatment plots were treated a second time on 6 October 1994 and the effects of the treatment were monitored on 18 November. Results were analyzed using the Students t test ($P \leq 0.05$).

Results

Mean numbers of active fire ant mounds were not statistically different: 20.33 versus 17.07 for treated and untreated control plots, respectively (d.f. = 17; P = 0.4141; F = 1.11)(Table 1). One month following treatment, Amdro® treated plots had significantly fewer active ant mounds than the untreated control plots (1.67 versus 8.73 for treated and untreated control plots, respectively (d.f. = 17; P = 0; F = 99999.99)), an 80.9 percent reduction. During the week of 16 October 1994, Montgomery County received flooding rains (31 inches of rain). The lower subplots/transects may have been flooded temporarily. However, the remaining area in this trial was not flooded. The 6 October treatment resulted in 86 percent reduction in numbers of fire ant mounds in treated plots versus untreated plots by 18 November (67/472).

Discussion

Results from monitoring the number of active fire ant mounds using the minimal disturbance method reported here are being correlated with results of methods to monitor foraging ant recruitment to bait stations by Jim Martin. Correlations results will be help improve decision making in fire ant suppression programs.

Long-term fire ant suppression studies are seldom undertaken. However, such studies are help document potential resistance of fire ants to insecticides. Although physiological resistance to insecticides is not anticipated to occur in fire ants because of their long reproductive cycle, behavioral resistance and avoidance of bait-formulated products remains a concern, particularly in light of recent resistance to cockroach bait formulations (Pennisi 1993). Long-term suppression program monitoring is also useful for documenting successful treatment programs utilizing sequential treatments of one or more insecticide as in the two-step method (Merchant and Drees 1993). These programs are often initially based on the combined results of short-term studies. Finally, long-term studies are required to document long-term ecological and economic effects caused by fire ants and/or fire ant treatments. Changes in fauna and flora are not expected to occur quickly.

Sterling (1984) discussed the concept of action levels and inaction levels. As economic injury levels (EILs) are developed for the red imported fire ant in agricultural situations, the concept of an economic threshold (ET) or action level (set below the EIL to allow action to be taken before that level is reached) will become a useful method to improve decision-making in fire ant management programs. The inaction level, justifying no chemical treatment for the cotton boll weevil occurs when four or more red imported fire ants are collected per 10 samples of cotton plant terminals using the beat bucket method (Knutson et al. 1993). Re-treatment thresholds that differ from the economic threshold for an initial treatment are established for certain pests such as the cotton bollworm and tobacco bollworm (Knutson et al. 1993). This integrated pest management (IPM) concept can also be useful for managing the red imported fire ant.

In the development of re-treatment thresholds for applying bait-formulated products for the suppression of the red imported fire ants, there is a need to consider cost (per mound and per acre), fire ant biology, desired level of suppression in time, and residual suppression provided by the treatment. The approximate per acre cost of a conventional fire ant bait treatment is $10.00 per acre and a reasonable average cost of an individual mound treatment is $0.50 (ranging from $0.17 to over $1.50). Using this price, one could treat about 20 mounds at $0.50 for the price of one $10.00 broadcast treatment.

Treatment using a broadcast bait application is already discouraged in areas with less than 20 mounds per acre based on concerns for non-target ants (Drees and Vinson 1993). Fire ant foraging must occur in the treatment area in order for particles from a broadcast bait treatment to be collected, carried back to mounds and fed to the colony. Therefore, a reasonable re-treatment threshold for bait products may be 20 to 30 or more mounds per acre.

There are a number of potential reasons for broadcast bait treatment failures. These include: 1) stale product and fertilizer blends; 2) low rate and poor coverage; 3) no ants actively foraging at time of treatment (too hot or too cold) or rain during or shortly after treatment; 4) contact insecticide applied sometime prior to treatment, suppressing foraging activity; 5) occurrence of flooding after application of a slow-acting bait causing treated colonies to float or migrate in or out of the treated area; 6) high initial mound density requiring additional applications to achieve acceptable suppression levels; and 7) no ants present because of successful prior treatments. If a product claiming to provide long-term suppression is applied when no ants are present to collect the bait, the bait quickly degrades in the environment and the possibility of rapid recolonization of ants begins shortly following application. Use of re-treatment thresholds, rather than use of a calendar-based treatment schedule can prevent this likelihood and optimize time between treatment intervals. This method can take advantage of natural environmental and seasonal ant suppression conditions such as periodic droughts and freezing winter conditions.

Acknowledgement

The authors are grateful to American Cyanamid for providing product support for this project. We also wish to thank personnel at the San Jacinto River Authority for their cooperation in allowing use of the land behind Lake Conroe dam and assistance in mowing plots. Funds for this project were provided through the Research Enhancement Program of the Texas Agricultural Experiment Station.

Literature Cited

Drees, B. M. and S. B. Vinson. 1993. Fire ants and their management. B-1536. Texas Agricultural Extension Service, The Texas A&M University, College Station, Texas.

Knutson, A., R. D. Parker, R. L. Huffman, C. G. Sansone and J. Swart. 1993. Management of cotton insects in the southern, eastern and blackland areas of Texas. B-1204. Texas Agricultural Extension Service, The Texas A&M University, College Station, Texas.

Merchant, M. E. and B. M. Drees. 1993. The two-step method do-it-yourself fire ant control. L-5070. Texas Agricultural Extension Service, The Texas A&M University, College Station, Texas.

Pennisi, E. 1993. How a cockroach lost its sweet tooth. Sci. News 143:27.

Sterling, W. 1984. Action and inaction levels in pest management. B-1480. The Texas Agricultural Experiment Station, Texas A&M University, College Station, Texas.

Table 1. Active fire ant mounds in 30 by 160 ft. (0.11 acre) transects across treated and untreated 3.47 acre plots, Lake Conroe Dam, Montgomery Co., Texas 1994.

	Plot (Treated/Untreated)									
Transect	1T	2U	3T	4U	5T	6U	7T	8U	9T	10U
24 May 1994										
A	31	21	15	19	21	14	22	6	17	16
B	28	21	14	15	34	18	30	24	8	21
C	7	8	11	7	25	20	20	29	22	17
A-C	66	50	40	41	80	52	72	59	47	54
27 June 1994										
A	1	8	0	6	0	22	1	6	3	9
B	1	10	2	13	4	13	0	2	3	4
C	3	15	2	7	2	10	0	7	3	9
A-C	5	33	4	26	6	45	1	15	9	22
18 Nov. 1994										
A	2	8	0	38	6	43	0	31	10	25
B	4	21	1	31	11	53	5	16	1	38
C	3	39	12	50	7	42	4	22	1	15
A-C	9	68	13	119	24	138	9	69	12	78

Effects of the imported fire ant on wildlife, Lake Conroe Dam, Montgomery Co., TX: Preliminary fire ant activity on managed plots over time.

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Texas A&M University, College Station, TX 77843

Introduction

Relative recruitment rates of the imported fire ant to bait were examined over an 11 month period, below Lake Conroe Dam, Montgomery Co., TX. This study is ongoing and is part of a larger experiment that endeavors to examine the impact of the imported fire ant on wildlife and the native rodent fauna in south east Texas in particular.

Materials and Methods

A 35-acre field (732m x 146m) was divided into 10 plots of 3.5 acres (73m x 146m). Half the plots were treated with the ant control agent Amdro©; the other half were left untreated. These plots were established in alternating bands. Three transects of 732 m each were extended running across the field. A bait station was established every 12 m. A total of 183 stations were created with 61 stations in each of the three transects. Each bait station was assigned both a unique identification number that enabled us to track unusual observations and a positional number that corresponded to the distance from the center of each plot. The positions range from 0 to 6, 0 being the center of the treated plots, 6 being the center of the untreated plots, and 3 being the border between treated and non-treated plots.

Once a month baited vials were laid down at each station. The dry cat food Deli-cat© was used for bait. The bait was moistened just prior to being deployed so as to increase its attractiveness to the fire ants. The vials were left out in the field for 90 minutes and then collected. Air temperature during the time of the survey was always in the range of 20 to 30 degrees C. Collection times were in the early morning in the summer months and late in the afternoon in the winter. The ants that recruited to the baited vials were counted.

Results and Discussion

A pretreatment recruitment count was taken across the field in early May of 1994. No significant differences between positions where found for pretreatment recruitment. Amdro© was applied to the field in late May and again in November. Recruitment activity after treatment was observed for eight of the following eleven months, excluding October, December, and April. Significant differences in recruitment were found between treated plots and untreated plots in all of the post treatment months. The hotter and drier months of June, July, August, and September had roughly four times as many ants recruit to the center of the untreated plots as compared to the center of the treated plots. The average numbers of ants captured corresponding to their field position are shown in Figure 1.

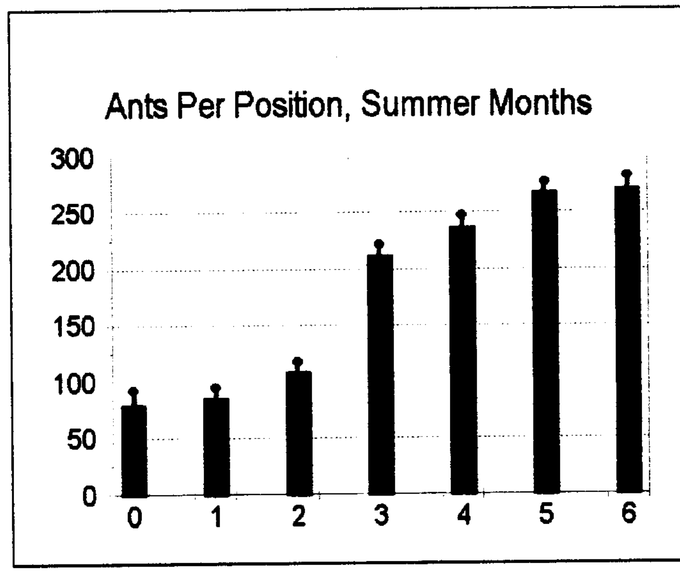

Figure 1

The cooler and wetter months of November, January, February, and March also had a like pattern, but with a much lower number of ants overall. Average numbers for ant recruitment in the winter months are shown in Figure 2.

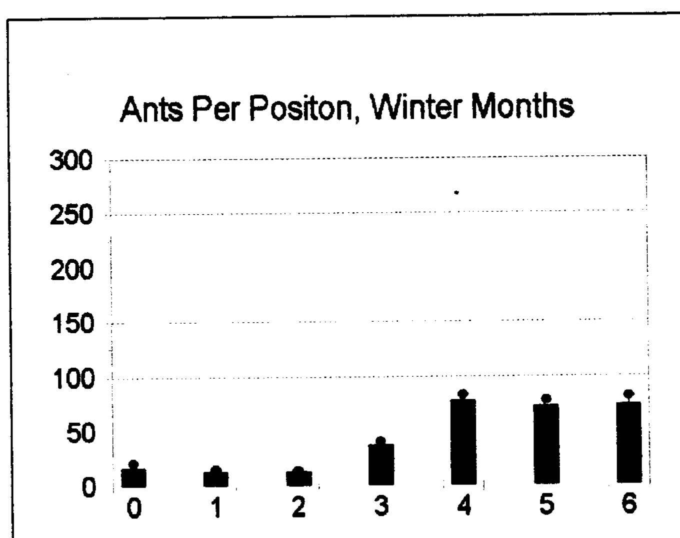

Figure 2

Though fire ants were not completely excluded from any portion of this field, the number of ants recruiting to bait was much lower in treatment areas.

Effective mound reduction in treatment areas (see Drees, this volume) indicate that in order for ants to recruit in these areas scouts and reserves had to travel a great distance. The lower densities of scouts patrolling treated areas and the consequently longer periods of time before resources can be harvested create havens for certain species of rodents (see Pedersen, this volume).

EFFECTS OF THE IMPORTED FIRE ANT ON WILDLIFE, LAKE CONROE DAM, MONTGOMERY CO., TX: PRELIMINARY ANALYSIS OF SMALL MAMMAL RESPONSE

E. K. Pedersen[1], W. E. Grant[1], S. B. Vinson[2],

M. L. Longnecker[3], and B. M. Drees[2]

INTRODUCTION

The red imported fire ant (Solenopsis invicta) is an exotic species introduced to the US half a century ago and currently spreads over 100 million ha. Imported fire ants reportedly cause reductions in native arthropod fauna (Porter and Savignano 1990). Although experimental studies report alteration in habitat use by small mammals in the presence of fire ants (Smith et al. 1990, Killion and Grant 1993, Stoker 1993, Ferris 1994, Killion et al. 1995) the effects are subtle, and some reports are contradictory. The objective of this study was to examine experimentally habitat use patterns of small mammals in the presence versus the absence of fire ants.

METHODS

This study was conducted at the San Jacinto River Authority compound at Conroe Co. SW of Houston, TX, from May 1994 to April 1995. The study area consisted of a 3.24 ha open grassland located SE of Conroe dam (Fig. 1). Five alternate areas (72 x 45m each) were treated in May 1994 with ant poison (Amdro ®, active ingredient: amidinohydrazone 0.88%) to reduce density of fire ants (treated areas). The remaining five areas contained naturally occurring densities of fire ants (untreated areas). Three 720 m long parallel transects perpendicular to the treatments

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were established. Along each transect 61 trap stations were placed 12 m apart. One Sherman live trap baited with bird seed was placed at each trap station.

Trapping occurred 5 consecutive nights each month, except for October. Traps were set at dusk and checked early in the morning. During the first night of the month, and as needed thereafter granulated fire ant contact poison (Diazinon 5%) was placed underneath each trap, regardless of treatment. This procedure was necessary to prevent fire ant-induced trap mortality.

Traps were checked in the morning from 07:00-13:00 during winter and from 06:00-10:00 during summer. Each small mammal captured was identified to species, weight was measured, sex determined, and age estimated. All animals were identified uniquely with a numbered metal ear-tag. After data collection, the rodent was released at the capture location.

Data were divided in two periods, summer and winter. Fire ant activity was the criterion used for data partitioning. In summer (June-September) fire ant activity was high (see Martin et al. this volume). In winter (November-April), there was low fire ant activity. Data from all trap stations were pooled into three groups: (1) treated--trap stations within treated areas, (2) untreated-- trap stations within untreated areas, and (3) border--trap stations located at the border between treated and untreated areas.

RESULTS AND DISCUSSION

Trap success was low (5%) during the study. The cotton rat (*Sigmodon hispidus)* was the most abundant species captured during summer (93% of all captures), and the pigmy mouse (*Biomys taylori*) was the most abundant species captured during winter (94% of captures). The white-footed mouse (*Peromyscus leucopus*) and the harvest

(94% of captures). The white-footed mouse (*Peromyscus leucopus*) and the harvest mouse (*Reithrodontomis* sp.) were present in the area but were excluded from the current analysis due to low numbers.

During summer, cotton rats were captured more frequently in treated (49% of all summer captures) than in untreated (14.21%) areas. Border captures were intermediate (30.68%) (Fig. 2a). Pigmy mice were virtually absent during summer 1994. Pigmy mice were relatively more abundant in border (3.23% of all summer captures), than in treated (1.42%) or untreated (0.71%) areas. In winter, pigmy mice were evenly distributed between treated (34% of all winter captures), untreated (38.29%), and border areas (25.50%) (Fig. 2b). Cotton rats rarely were captured during winter 1994-95. Cotton rats were relatively more abundant in untreated (0.94%) than in treated (0.71%) or in border (0.54%) areas.

Thus, based on our preliminary analysis, cotton rats appear to alter habitat use due to the presence of fire ants during summer, when activity of cotton rats and fire ants overlap. During winter, when fire ants are less active, pigmy mice show no change in habitat use induced by fire ants. Because small mammal populations fluctuate broadly between years, it is possible that the relative abundance of species will change as trapping continues. We expect to obtain similar results for pigmy mice, as observed for cotton rats, if captured during summer. Similarly, we expect to find no differences among cotton rat captures in treated and untreated areas during winter.

LITERATURE CITED

Ferris, D. K. 1994. Impact of Solenopsis invicta on small mammal habitat utilization and abundance. Ph.D. Dissertation, Texas A&M Univ., College Station.

Killion, M. J, W. E. Grant, and S. B. Vinson. 1995. Response of Baiomys taylori to changes in density of imported fire ants. J. Mammal. 76:141-147.

Killion, M. J., and W. E. Grant. 1993. Scale effects in assessing the impact of imported fire ants on small mammals. Southwest. Nat. 38:393-396.

Porter S. D, and D. A. Savignano. 1990. Invasion of polygyne fire ants decimates native ants and disrupts arthropod community. Ecology 71:2095-2106.

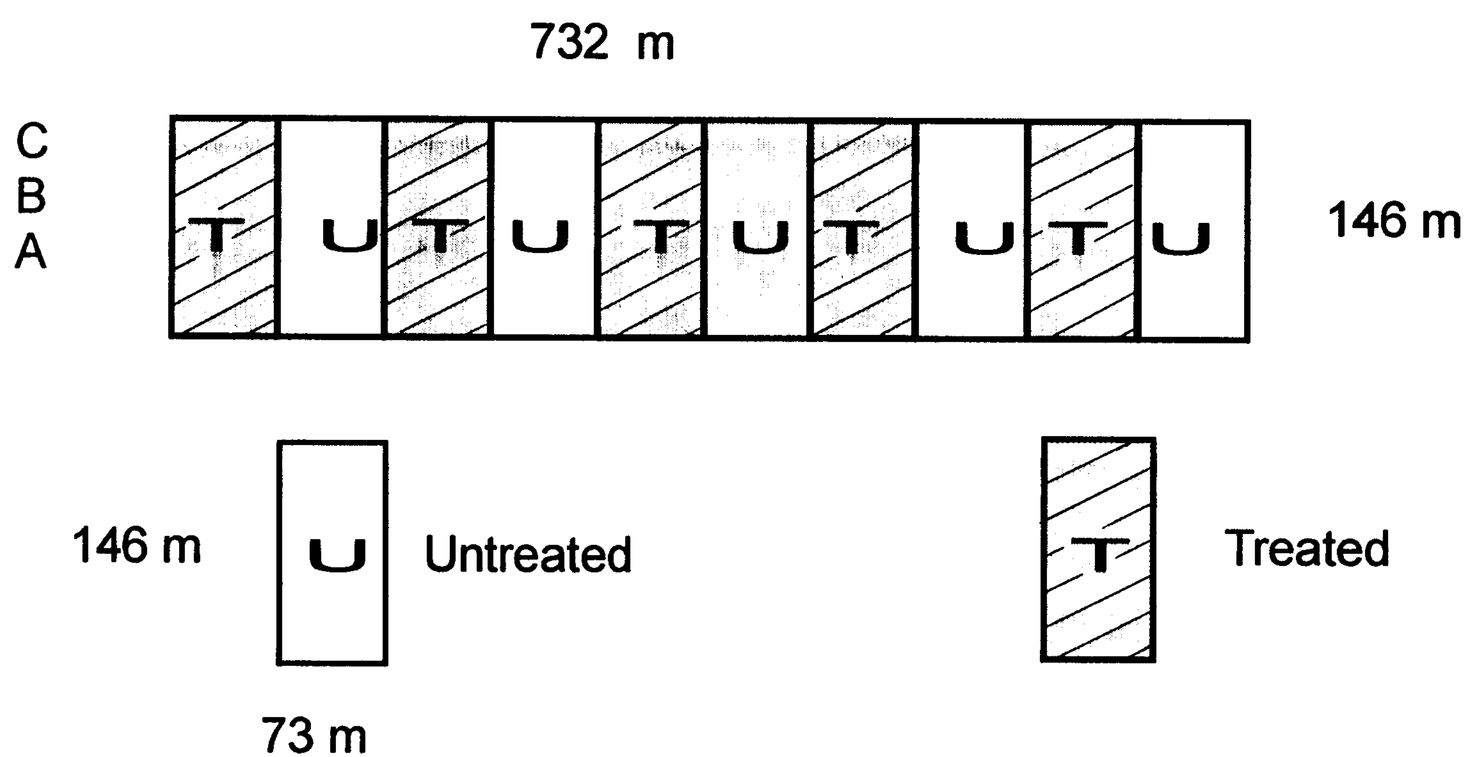
Smith, T. S., S. A. Smith, and D. J. Schmidly. 1990. Impact of fire ant (Solenopsis invicta) density on northern pygmy mice (Baiomys tailory). Southwest. Nat. 35:158-162.

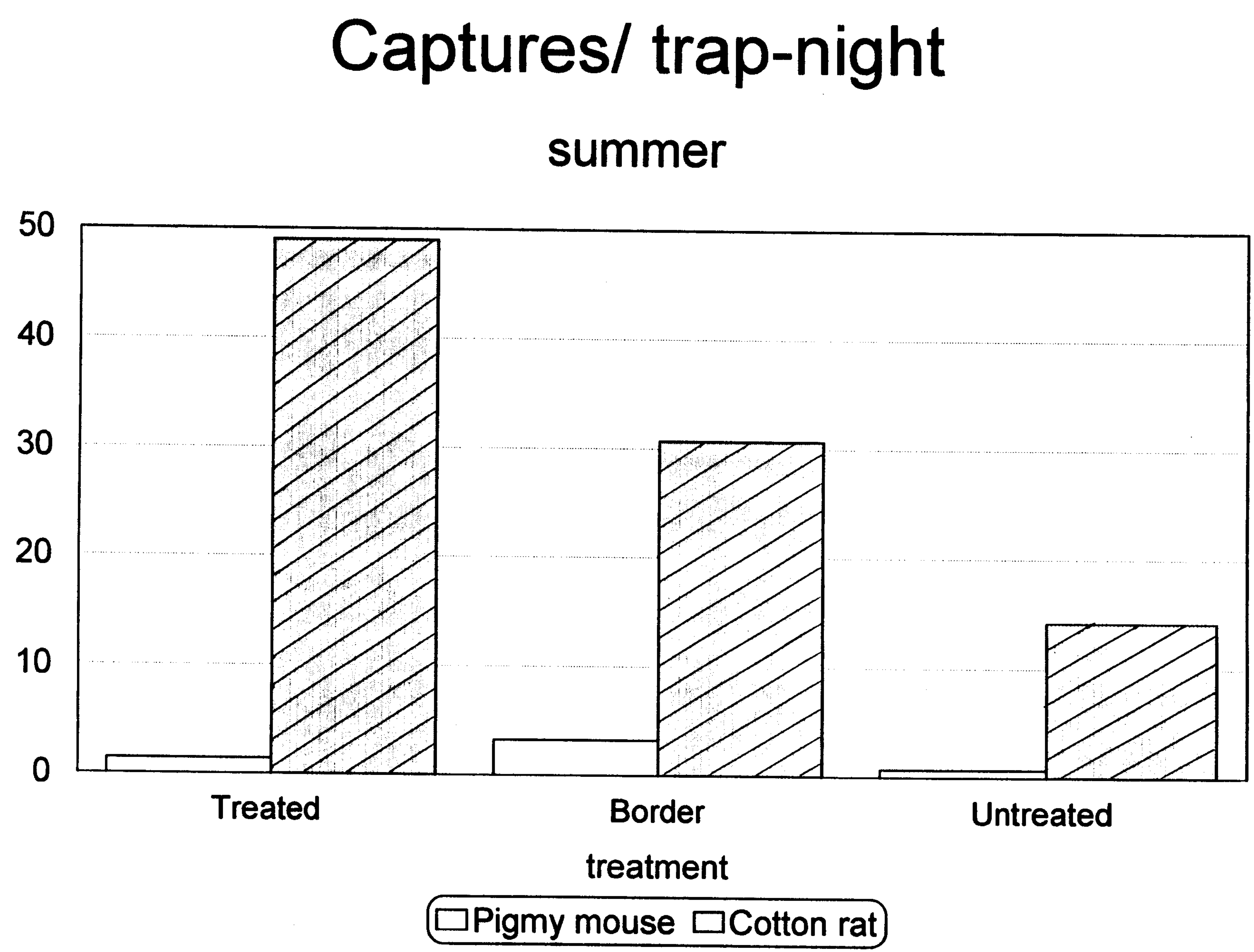
Stoker, R. L. 1993. A hierarchical perspective on the ecology of biological invasions: Impact of red imported fire ants on grassland ecosystems. M. S. Thesis, Texas A&M Univ., College Station. 66pp.

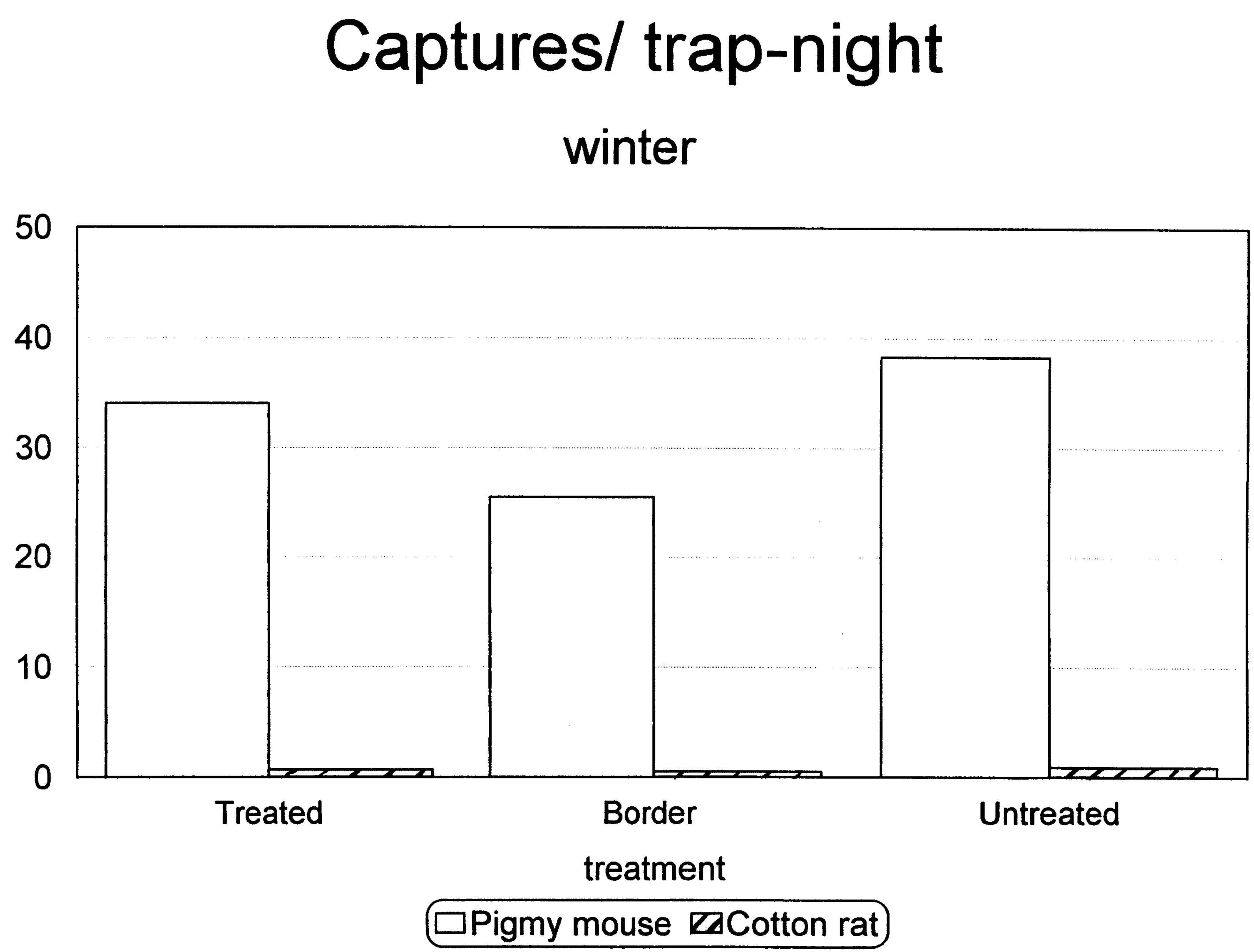
Fig. 1 Diagram of study area at San Jacinto River Authority, Conroe County, TX, indicating locations of treated and untreated areas.

Fig. 2 Captures/trap night for cotton rats and pigmy mice in Conroe Lake study area from November 1994 to April 1995 in treated, untreated, and border areas during (a) summer, and (b) winter.

Study area




Captures/ trap-night
summer
50
40
30
20
10
0
Treated
Border
Untreated
treatment
Pigmy mouse
Cotton rat


Captures/ trap-night
winter
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0
Treated
Border
Untreated
treatment
Pigmy mouse
Cotton rat

USING HISTORICAL USFWS BREEDING BIRD SURVEY DATA TO ASSESS FIRE ANT IMPACT ON BIRDS

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Summary

We used a statistical method designed to integrate both positive and negative aspects of imported fire ant influences on birds. This analysis included: 1) Fire ant invasion of Arkansas and Texas counties by year. 2) U.S. Fish and Wildlife Service's Breeding Bird Survey for the years 1968-1992 based on bird species counts by experienced "birders" on standardized census routes. 3) Since non-fire ant caused variability in bird counts in time and space is substantial, data were filtered prior to running our model. 3) Yearly influence of fire ants was modeled as a change in densities after fire ants invaded counties. 4) Data on 34 bird species that are common summer inhabitants of southern states were analyzed.

Depending upon species, our analysis showed that after fire ants moved into counties bird densities increased or decreased. Although several species showed substantial changes in densities, because of great variability in the data, no differences were statistically significant. Species with notable changes included:

Downy woodpecker	+11%	Field sparrow	-5%
Eastern blue bird	+7%	Tufted titmouse	-5%
American crow	+5%	Chipping sparrow	-11%
Eastern meadowlark	+5%	Mockingbird	-14%.

The Northern bobwhite, an important game species, showed only a -2% change. Applying this statistical method to another large bird data base, the Christmas Bird Count, may provide additional collaborative information.

This research was funded in part by USDA APHIS grant 94-8100-0229-GR to LCT, and the results do not necessarily express APHIS' views. Published with permission of the Director, Arkansas Agricultural Experiment Station, Fayetteville.

Control of Imported Fire Ants
Around Poultry Production Houses, 1994

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1995 Imported Fire Ant Conference
May 2-5, 1995
San Antonio, TX

INTRODUCTION:

Due to their omnivorous feeding habits, fire ants are capable of inflicting damage to a variety of crops, wildlife, and other lifeforms. A considerable amount of anecdotal evidence indicates that fire ants cause several types of damage to poultry production. In some instances, baby chicks are directly stung by the ants. Foraging worker ants are also attracted to the feed, and in some cases have been known to cause electrical shorts in various types of equipment. However, very little research on these effects have been conducted, and damage has not been fully documented. Most of the studies that have been conducted have concentrated on determining the level of fire ant control following various insecticide applications. Lovelace and Kissam (1991) reported that the primary problem with fire ants in South Carolina turkey grow-out houses was that ants build their mounds outside the houses and forage on dead birds inside the houses. This creates problems for farm workers that collect dead birds and work in the houses. Wright, Bochat, & Parker (1991), and Wright and Parker (1992), found that similar problems occur in Texas broiler houses. They also reported that broiler growers on some poultry farms reportedly spend $300 to $500 per house per year for control of fire ants. Sparks (1991) found that a control program consisting of a broadcast application of LOGIC® bait in combination with spot treatment with ORTHENE® provided good control of fire ants outside chicken houses in Barrow County, Georgia.

In 1994 poultry and egg production in Mississippi was valued at $1.08 billion replacing timber as the top agricultural product in Mississippi. This is the first time poultry production has topped the $1 billion in the state. Poultry production accounted for 24% of all farm production (Progressive Farmer, March 1995).

MATERIALS AND METHODS:

In February, 1994, 100 questionnaires were sent out through McCarty Farms to their poultry producers. A copy of this questionnaire is shown as Figure 1. From the producers who responded to the questionnaire, 10 were selected to participate in a control study.

Several bait control technologies were evaluated. Both broadcast treatments and spot treatments with AMDRO® (American Cyanamid Company, Princeton, NJ), and LOGIC® (Ciba Geigy Corporation, Greensboro, NC) were made on June 14 and 15, 1994. Effectiveness of the following treatments was determined:

TREATMENT NO.	TREATMENT PROCEDURE	APPL. RATE (Per Label)
1	Spot treat with Amdro	5 Tablespoons/nest
2	Spot treat with Logic	3 Tablespoons/nest
3	Broadcast with Amdro†	1.5 lbs./acre
4	Broadcast with Logic†	1.5 lbs./acre
5	Untreated Check	-

† Broadcast treatments were one "swath" in width, (ca. 20' with the Herd® GT-77 granular applicator).

Each treatment was replicated 5 to 7 times. Spot treatments were applied to all 4 sides of each house; any fire ant nest within 5' of the exterior wall was treated at labelled rates of application. Likewise, strip treatments were applied to all 4 sides of each house at the labelled rate of application. Prior to application, the fire ant population was determined by counting and characterizing each fire ant nest within 5' of the exterior walls using the population indexing system described by Lofgren and Williams (1982). Posttreatment population assessments were conducted at 8 week intervals. Spot treatments were applied manually, and broadcast treatments were applied with a Herd GT-77 granular applicator mounted on a Suzuki® ATV. Experimental data was statistically analyzed using Analysis of variance and an LSD test ($P=0.05$) for each post-treatment rating interval.

RESULTS:

Twenty-seven of the 100 questionnaires were returned, and all respondents indicated that fire ants were a problem on their farm. The most common complaint was that the ants accumulated on dead birds and stung workers who were in the process of removing them. Premature rusting and deterioration of tin around the base of house was also frequently mentioned.

Data collected in the control study are shown in Tables 1 & 2. At 8 weeks after treatment, all treatments had significantly decreased the population indices as compared to the untreated check populations. However, there was no significant difference between numbers of colonies present in the treated and untreated plots (i.e. colony mortality). At 16 and 24 weeks after treatment, no differences in treated and untreated populations were detected.

Limited, but unsatisfactory, control was achieved with both Amdro and Logic in this study. The superabundance of alternate food sources, such as chicken feed, fly pupae, etc., may have rendered both baits less attractive, therefore were not ingested.

Table 1. Activity of Fire Ant Baits Applied as a Broadcast or Individual Mound Treatment Around Poultry Broiler Houses: Effect on number of Colonies Present.

Treatment	Application	Mean % decrease in no. colonies†		
		(8)	(16)	(24)
Amdro	broadcast[1]	36.9a	20.8a	31.0a
	ind. mound[1]	40.3a	26.3ab	29.0a
Logic	broadcast[1]	49.8a	58.1b	40.2a
	ind. mound[2]	51.2a	34.3ab	31.1a
Check[3]		30.4a	39.1ab	34.7a

Table 2. Activity of Fire Ant Baits Applied as a Broadcast or Individual Mound Treatment Around Poultry Broiler Houses: Effect on Population Index.

Treatment	Application	Mean % change in population index†		
		(8)	(16)	(24)
Amdro	broadcast[1]	-66.5a	-39.3a	-30.7a
	ind. mound[1]	-65.0a	-55.3a	-31.7a
Logic	broadcast[1]	-76.8a	-66.7a	-36.4a
	ind. mound[2]	-86.6a	-59.1a	-43.2a
Check[3]		-29.8b	-48.1a	-42.1a

† means within a column followed by the same letter are not significantly different according to LSD test, P=0.05.

[1] mean of 6 replicates
[2] mean of 5 replicates
[3] mean of 7 replicates

Fire Ant Questionnaire
for
Mississippi Broiler Producers

1. Are fire ants a problem on your farm
   - 26 - Yes
   - 1 - No

2. If fire ants are a porblem, what type of damage do they cause?
   - 23 - Sting workers that pick up dead birds
   - 17 - Eat the chicken feed
   - 15 - Don't kill baby chicks, but sting their feet causing sores, etc.
   - 14 - Cause problems in electrical junction boxes
   - 7 - Kill baby chicks by directly feeding on them

   Other comments
   - -Mounds built up around curtains and end doors
   - -Mounds built up along sides of building damages tin siding (2)
   - -Ants cover dead chicks (hard to pick up)
   - -Air conditioner compressor damaged (cost $1120.00)
   - -Ant mounds inside walls also damage tin siding and baseboards (2)
   - -Infections in workers stung by ants

3. Do you think fire ants cost you money?
   - 23 - Yes
   - 0 - No
   - 3 - Don't Know

4. If fire ants cost you money, how much would you estimate?
   - Avg - $676.00 per year
   - Rng - $30.00 - 2000.00
   - (based on 5 responses)

5. Do you spend money on fire ant control?
   - 21 - Yes
   - 5 - No
   - 1 - No response

6. If you spend money on fire ant control, how much?______$ per year.
   - Avg - $148.80
   - Rng - $25.00 - 700.00
   - (based on 18 responses)

7. If there were effective baits for fire ant control that *could be used outside the houses*, would you use them?
   - 17 - Yes
   - 0 - No
   - 0 - Probably not
   - 9 - Depends on cost
   - 1 - No response

8. How much per year would you be willing to spend on fire ant control?
   - Avg - 129.61
   - Rng - 30.00 - 700.00
   - (based on 13 responses)

References Cited

Lovelace, S.R. & J.B. Kissam. 1991. Observations of the red imported fire ant *Solenopsis invicta* Buren in turkey grow out houses and preliminary control investigations. *In*: Proceedings of the 1991 Imported Fire Ant Conference. (ed.) M.E. Mispagel, College of Veterinary Medicine, Univ. GA., Athens.

Sparks, B. 1991. Evaluation of a fire ant control program using Logic and Orthene around poultry houses, Barrow County, Georgia, 1991. Unpublished Report. Univ. of GA, Dept. of Entomol., Athens.

Wright, O.L., M.T. Bochat & R.D. Parker. 1991. Fire ant control on poultry farms with Logic fire ant bait. *In*: Results of 1991 Agricultural Demonstrations - Gonzales County, Texas. Texas Agric. Exten. Service, Corpus Christi. pp. 55-57.

Wright, O.L. & R.D. Parker. 1992. Effectiveness of Logic bait for control of fire ants around poultry houses. *In*: Results of 1991 Agricultural Demonstrations - Gonzales County, Texas. Texas Agric. Exten. Service, Corpus Christi. pp. 43-44.

TEXAS CATTLE PRODUCER'S SURVEY: IMPACT OF RED IMPORTED FIRE ANTS ON THE TEXAS CATTLE INDUSTRY

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and
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The Survey of Texas Veterinarians (Barr, et.al., 1994) which surveyed 2500 veterinarians in Texas documented that the red imported fire ant *(Solenopsis invicta* Buren) causes injuries to livestock, pets, and wildlife that are somewhat infrequent, but costly when they do occur. However, many veterinarians indicated that a significant number of animal injuries and deaths are not reported to them by producers. Complaints heard from livestock producers and historical accounts (Lofgren, 1986) concern not only fire ant damage to animals themselves, but also electrical equipment, feed, hay bales, and many types of farm machinery. In addition, fire ants are blamed for reductions in forage and hay quantity, and wildlife populations.

To address these concerns, the Texas Agricultural Extension Service, with the sponsorship of Ciba Geigy Corp. and the assistance of the Texas and Southwestern Cattle Raiser's Association, conducted a survey of fire-ant related impacts on the Texas cattle industry. The overall objective was to gain detailed frequency and economic data on fire ant-related damage from cattle producers themselves. It is hoped that, using this information, methods can be developed to determine an economic injury level so that individual producers can conduct effective fire ant suppression programs.

Materials and Methods

The survey instrument was developed in conjunction with specialists in the areas of entomology, cattle production and pasture management. The survey was printed in an 8-page saddle-stitch format with a cover letter on the front and the entire back page left open for comments. Respondents were assured of confidentiality and no spaces were included for names or addresses, only county.

To help concentrate the survey on "serious" cattle raisers, those who are in closer contact with their herd and who maintain more detailed financial records, the mailing list was provided by the Texas and Southwestern Cattle Raiser's Association (TSCRA). To obtain a geographically thorough distribution, survey recipients were chosen by randomly selecting fire ant-infested counties. Those counties with large urban centers were avoided due to high concentrations of absentee landowners. The list of 72 counties was sent to TSCRA who printed out a list of all members in those counties - a total of 4,521. Survey mailouts included the survey and a postage-paid return envelope in a large manila envelope. To maintain confidentiality of the mailing list, the surveys were transported to a mailing service used by the TSCRA in Fort Worth, Texas where they were addressed and mailed.

Surveys were mailed on or about 1 December 1994. The TSCRA provided 2 reminders in newsletters in mid-December and February. Surveys were opened and given a sequential identification number upon receipt. The last surveys included in tabulations were received on 15 March 1995. To ensure as much uniformity as possible with very non-uniform responses, data were entered into a Paradox 4.5 database ***solely*** by the senior author who made every attempt to standardize responses for accurate analysis. All comparative agricultural data was obtained from the 1992 Census of Agriculture (U.S. Dept of Agriculture, 1992).

Results and Discussion

Due to the detail of the survey instrument and magnitude of the response, a full analysis of the data is incomplete at this time. Also, it is not possible to cover more than the most concise summary of the results and include detail on the most significant findings here.

I. General Response Statistics. A total of 1540 surveys were returned, a rate of 34.0% and 1.04% of the total number of farms in Texas (Table 1). Of these respondents, 1,090 or 70.7%, reported "Yes", that they have experienced fire ant-related economic losses. Respondents were first asked to list the county(ies) in which they grazed cattle (own or lease) and corresponding acreage. Approximately 20% of respondents listed more than one county. Acreage responses were received from 166 different counties and all but 1 of the targeted counties.

A total of 3,208,998 acres were listed by respondents, accounting for 3.12% of all pastureland in the state of Texas (an area larger than Connecticut) and 4.67% of the land in fire ant-infested counties. Of this total, 1,650,935 acres were reported by "Yes" respondents and 1,558,063 by "No" respondents (Table 2). Note that "No" respondents are much larger landholders than those responding "Yes", 3,795 ac. vs 1,515 ac. respectively, due largely to changes in stocking rate and fire ant density as one moves west and south across Texas (Table 3). It should also be noted that these results may be skewed by 2 "No" respondents who reported a total of 300,000 acres.

The most obvious thing about the overall results are their sheer numbers. A return rate of 34% for such a long and very detailed survey is truly remarkable. The survey contained space for 250 possible answers, mostly fill-in-the-blank. Fifty to 100 were commonly answered by "yes" respondents. Also remarkable was the geographic coverage of returns. Of the 167 infested counties (according to TAEX entomological records), 144 had responses while 22 uninfested counties reported.

The main area of non-reporting counties was along the extreme eastern edge of the state and a few counties on the Gulf Coast. Curiously, this area of East Texas is the same that failed to respond to the veterinary survey. It is also the area that has been infested with fire ants the longest in Texas. One can only guess the reasons as to why both veterinarians and cattle producers failed to respond. Perhaps they have just learned to live with fire ants. Perhaps they just don't like to answer surveys.

II. Impacts in Hay Production. Of the 1,090 "Yes" responses, 580 in 92 counties indicated that they had experienced ant-related problems with hay production, 312 with storage problems (multiple responses allowed) and 224 with no problems associated with hay. Of those 580 "yes" responses, 545 included acreage figures for a total of 73,004 acres, 2.02% of the state's hay pasture total. The average hay pasture size was 134 acres, compared to 46 acres for the state. This figure may be large due to the size of the landholdings and since some of the larger responses were totals from custom baling operators who hay others' pastures.

Respondents were asked to provide details about their hay production and per bale profit per cutting. Many respondents who did not report having fire ant problems filled in this section anyway for a total of 453 responses. Those producing large round bales accounted for 84% of the responses with an average yield for a first cutting of 3.5 large round bales per acre and a profit of $11.96 per bale.

A total of 140 respondents (24.1% of those reporting some hay-related losses) answered the question regarding purchase of new machinery as a result of fire ant activity, reporting a total expenditure of $835,425 or $5,967 per respondent. For the analysis of costs associated with repair of damaged machinery, care was taken to ask the respondents about both material and labor costs and how often these costs were incurred. In summary, 267 respondents filled out all 3 parts of the question - cost of parts, cost of labor, and frequency of these amounts. Total costs amounted to $270,407 or an average of $1,012.76 per respondent per year. These same respondents reported hayed acreage of 40,557 (1.31% of total hay acreage in infested counties) or **$6.67 per acre per year.**

Ranchers were asked to estimate the number of times they stop during a cutting to unclog fire ant-caused jams and for how long per stop. They were also asked to estimate their hourly labor and machine-time costs. A total of 247 respondents completed the 3 parts of this question - number of times stopped during a cutting, how many minutes per stop, and the hourly cost of this time including machine time and labor. They stated that they stopped an average of 27 times per cutting for an average of almost 17 minutes each time. They also stated that their hourly costs were $24.92. This group reported a total of 34,380 acres or 144 acres per respondent. All of this averages out to **$0.88 per acre.** Some respondents commented that this number of stops only occurs during the first cutting of a season when mounds are more numerous, freshly built, and muddy.

As a result of so much damage and so many stops, many producers raise the hay cutter bar to avoid fire ant mounds. There are two ways this is done: raising it a few inches over the entire field and/or adjusting it continuously to avoid individual mounds. Cutter bars were raised over the entire field an average of 3.5 inches as reported by 184 respondents. Of these, 173 accounted for 24,370 total acres. Only 52 respondents reported adjusting cutter bars continuously, but raised them a much greater average of 5.4 inches.

The respondents were then asked to estimate how much hay production raising the cutter cost them. Due to a wide variety of units in response, determining an exact dollar value was quite difficult. Nevertheless, results from about 50 respondents indicate that avoiding mounds by either means causes a production loss of about 0.5 large round bales per acre, on the order of 15%. Using the production figures, that loss translates to about **$6.00 per acre** on at least one cutting.

The comments section provided tremendous insight into how fire ants affect hay production. Several respondents stated that it was necessary to move bales, particularly square bales, out of the field before nightfall or a large portion of them would be infested before morning. Some baling crews will not handle square bales from heavily infested pastures out of concerns for worker safety. Still other comments from ranchers who do not bale their own hay indicate that custom balers have increased prices 10-15% solely because of the extra time and trouble associated with fire ant infestations. Still more comments indicated that there are serious losses in time because equipment must be driven more slowly across fire ant-infested fields. To alleviate problems, other respondents reported dragging their fields to knock down mounds at reported costs of up to $10 per acre.

Therefore, not counting costs of new machinery, which would be depreciated over several years, off-ground storage costs, or the other factors for which there is insufficient data, fire ant-caused losses to these hay production are as follows:

Repairs and lost labor due to breakage	$6.67
Stops to unclog jams (assume per year)	$0.88
Raised cutter bar/lost production (once)	$5.98
	$13.53 per acre per year

The responses to the section on hay production were, by far, the most complete and detailed of the entire survey. Though the response was great, there were perhaps an equal number of ranchers who have their hay cut and bailed by others and could not give such specific information. The outcome of this section, a per acre per year cost of $13.55, was both surprising yet logical when the problem is broken down into its components.

Take, for example, the figures on cleaning out jams in hay machinery. Stopping 26 times per cutting may sound like a lot, but not when the average pasture size is 144 acres. That is only one stop per 5.5 acres. Similarly, 17 minutes to clean out a clog is quite reasonable. Tools must be on hand, panels removed, the clog untangled, and the whole thing reassembled - this with the area covered in angry fire ants. Many times were in the 30-45 minute range with comments that the equipment had to be taken back to the workshop to, if nothing else, working in a fire ant-infested field.

The question also arises as to whether these various economic losses are counter-indicative. In other words, if a rancher buys a disc-type cutter and raises it 4 inches, will he still suffer losses from breakdowns and jams? A review of individual surveys and a knowledge of hay production suggests that the answer is, to a large degree, yes. Even if a disc-type cutter knocks down the mounds without breakage, they still require more frequent tooth sharpening and replacement than would a sickle-bar cutter because of these repeated impacts. By the time the hay is dry days later, the mounds are rebuilt enough to jam the baler just as often and that 4 inches of forage is still lost.

Perhaps the most obvious question that arises from these results is whether these economic losses occur in every hay pasture in the fire ant infested area of Texas? Obviously not. Losses depend greatly on the size and character of the mounds which depends on soil type, rainfall and density. Nevertheless, these numbers are <u>averages</u> from about 250 respondents. Some ranchers are experiencing *worse* losses, while others, none. These losses are not occurring everywhere, but they are occurring and there are producers suffering serious economic losses.

A $13.55 per acre per year, assuming that it does occur, can justify treatment of hay pastures with a chemically-based fire ant suppression program. Using currently labeled baits and ground application equipment, it is estimated to cost $10-12 per acre per year to satisfactorily suppress fire ants (Drees and Vinson, 1993). Easy equipment modification allows bait application simultaneous with other agronomic practices such as fertilization (unpublished data). This virtually eliminates the labor involved and brings the cost down to $8-10 per acre. Recently developed skip-swath application methods with fenoxycarb bait, though not approved for pasture use at the present time, can cut material costs in half. (Drees, et. al., 1993)

<u>III. Other Causes of Economic Loss.</u> Table 4 details a brief summary of all economic responses that were either reported directly or that could be calculated reliably from information given. Respondents in this and other sections usually rounded off their answers to even tens or hundreds of dollar. There were, however, respondents who obviously went into their computers or record books and extracted values to the penny. These two sets of values were well within range of each other. Responses that were far out of range, such as the man who valued his time at $200 per hour, were not included in final tabulations.

Losses due to cattle injuries and deaths are relatively minor compared to the size of the cattle industry as a whole - unless it's your cow. An average of $1,850 per lost animal is substantial, particularly for a small operation. We suspect that this number is somewhat inflated, probably by the natural tendency of respondents to report "memorable" losses, such as carefully bred calves and registered breeds. They may have also reported sale prices had the animal gone to market rather than net profits.

The section on equipment and material losses yielded several surprises. The first was the frequency at which these incidents occur. Over 78% of all "Yes" respondents reported something in this category with fully two-thirds reporting damage to electrical equipment, many indicating that these losses occur annually. Secondly, these losses are relatively unrelated to the size of individual operations. A $300 water pump can burn out due to fire ants on a 10 acre ranch just as easily and frequently as on a 10,000 acre ranch. The difference is that the owner of the 10 acre ranch can realistically and economically treat his entire place for ants, preventing such damage. The same does not hold true for the entire 10,000 acres.

The total dollar value of equipment and material losses came to about $0.84 per reported acre. Again, losses cannot be spread over acreage. A more accurate representation is the average loss per operation. Unfortunately, this can't be determined with great accuracy because not every respondent listed losses in every category. However, dividing the total loss by the number of producers that responded to at least one of the questions is a good approximation - $1,367. For a 10 or 100 acre ranch, losses of this magnitude can justify treatment costs. For a 1,000 acre ranch, cost is prohibitive.

Expenses related to pesticide treatment of fire ants totaled only about $400,000. When extrapolated to the total number of ranches in the infested areas, this comes to about $20 million. A substantial sum, but small compared to the state's $8 billion cattle industry. The interesting feature is the distribution of pesticide use. Almost every respondent replied to this question. Pesticide use around the home was reported by over 80% with the percentage decreasing steadily as the value of the site decreases. Unimproved rangeland received treatments by only 61 respondents. The cost of such treatments, however, did not follow such a pattern. Home use averaged $250 per respondent, but these people (most respondents used pesticides in both areas) used only $97 worth of chemicals around barns and outbuildings. Those who did treat their production land spent from $117 to $212. It is important to note that these figures are not per year or per acre.

Conclusions

Since the purpose of this survey was to gather data towards the development of economic injury levels on a per acre basis, the simple thing to do is to divide the reported losses by the reported acreage. Therefore, the figure for those respondents listing some economic loss equals **$2.06 per acre**. Extrapolating that figure to the "problem" areas of the state, the loss comes to $67 million. A large number, but still only 0.99% of the states 6.8 billion dollar beef cattle industry.

However accurate $67 million may be, its derivation is unrealistic. The survey shows that fire ant problems are not evenly distributed, even within a single county or a few square miles. It must be emphasized that this is an operation-by-operation phenomenon where treatment decisions must be made by each producer after analysis of his or her particular problem. One conclusion is clear, if fire ant damage occurs, it is usually significant to the individual, but the circumstances cannot be applied to his neighbors.

Without a doubt, fire ants are still an issue of major concern to Texas cattle producers. Though this impression is firmly supported by the return rate and geographic distribution it can only be fully appreciated by reading the voluminous comments included on the surveys. About 40% wrote something and many respondents filled the back page, several attaching extra sheets. Many respondents provided their names and addresses even though the confidentiality of their membership was of utmost concern to the TSCRA. Many respondents gave detailed descriptions of their location versus the location of the nearest fire ants or when they were first invaded, giving us an irreplaceable historical record of the fire ant's westward expansion. One gentleman even sent photos.

Survey results and comments point out a paradox that would seem to be peculiar to fire ants among other pests of agriculture - perceptions and opinions versus reality. Many respondents listed virtually no economic impact while reporting hundreds of dollars spent on control. Others listed thousands of dollars in losses, particularly regarding hay production, yet spent almost nothing on pesticides. What many respondents mentioned was the need for an eradication program similar to that conducted on the screw worm - a cheap, one-shot, government-sponsored effort that solves the problem.

Results indicate, among many other things, that there is tremendous confusion about fire ants and treatment options and a general condemnation of treatment costs and effectiveness. They also showed that there is an almost desperate need for education in the areas of impact and cost analysis, management options, and pesticide use. Based on this survey, the veterinary survey, and numerous fire ant control field experiments, the Texas Agricultural Extension Service is well on its way towards the development of an economic injury level for fire ants in individual cattle operations.

Acknowledgments

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Very special thanks to the cattle producers who took the time to give us this invaluable information.

Literature Cited

Barr, C.L. et. al. 1994. Texas veterinary survey: impact of red imported fire ants on animal health. Texas Agric. Ext. Serv., Texas A&M University, College Station, Texas. 43 pp.

Drees, B.M., C.L. Barr and M.E. Heimer. 1993. Skip-swath application of Amdro® and Logic® broadcast baits for the suppression of the red imported fire ant, pp. 69-72 *in* Proceedings of the 1993 Imported Fire Ant Conference (compiled by J.P. Ellis), Charleston, South Carolina.

Drees, B.M. and S.B. Vinson. 1992, 1993 (rev.). Fire ants and their management. TAEX B-1536. Texas A&M University System, College Station, Texas.

Lofgren, C.S. 1986. The economic importance and control of imported fire ants in the United States *in* Economic Impact and Control of Social Insects, S.B. Vinson (Ed.) Praeger Publishers. pp. 2322-251.

United States Department of Commerce, Economics and Statistics Administration, Bureau of the Census, 1994. 1992 Census of Agriculture (AC92-A-43), Volume 1, Part 43A and 43B. U.S. Government Printing Office, Washington, D.C. 20402

Table 1. Response statistics to the Texas Cattle Producer's Survey.

Number Mailed	4,521	Counties in Texas	254
Number Undelivered	3	Infested Counties	167
Number Returned	1,540	"Targeted" Counties	72
Return Rate	34.0%	Counties w/responses	166
"Yes" responses	1,090	Infested w/responses	142
"No" responses	450	Non-infested w/resp.	22

Table 2. Breakdown of acreage responses.

Total Texas pastureland	102,805,890 (61% of total land area)
RIFA infested pastureland (by county)	55,838,986 (54.3% of pastureland)
Acreage of targeted counties	28,613,193 (51% of infested area)
Total acreage listed on surveys	3,208,998 (3.1% of Texas total)
Acreage from infested counties	2,610,172 (4.7% of infested counties)
Acreage with "Yes" responses	1,650,935 (2.96% of infested area)

Table 3. Acreage, cattle and stocking rate characteristics of respondents.

	Avg. acreage	Cattle	Avg./Respondent
All respondents	2,083.8	299,282	-
"Yes" respondents	1,514.3	218,238	211
"No" respondents	3,795.3	81,044	206

Average stocking rate for Texas	7.76 acres/head
Average "Yes" respondent* stocking rate	7.58 acres/head
Average "No" respondent** stocking rate	19.22 acres/head

* Respondent indicating economic losses due to fire ants.
** Respondent indicating no economic losses due to fire ants.

Table 4. Summary of Losses and Expenses

Item		Responses	Total loss	Avg./resp. reporting loss[1]	Avg./"Yes" respondent[2]
Cattle Losses					
Injuries (# cows=1544)		378	$ 34,757	$121.10	$ 31.89
Deaths (# cows=793)		278	514,449	1,850.54	471.97
Sub-total			**549,206**		**503.86**
Equipment and Material Losses					
Ruined feed	material	359	155,386	432.83	142.56
	labor	219	22,975	104.91	21.08
Ruined hay	material	416	197,486	474.73	181.18
	labor	246	54,045	294.70	49.58
Shredder dmg.	material	304	155,242	510.66	142.42
	labor	243	71,620	294.73	65.71
Elect. equip.	material	687	259,719	378.05	238.27
	labor	504	96,678	191.82	88.70
Other	material	75	53,959	719.45	49.50
	labor	60	22,721	378.68	20.84
Sub-total			**1,089,831**		**999.84**
Hay Production					
New Equipment		140	835,425	5,967.32	766.44
Equipment Repairs		267	279,010	1,044.98	255.97
Jam Removal		247	45,027	182.30	41.31
Sub-total (not incl. lost production)			**1,159,462**		**1063.72**
Pesticide Use					
Home/living quarters		828	207,596	250.72	190.46
Outbuildings		686	66,138	96.41	60.67
Hay storage		562	54,635	97.22	50.12
Calving Pastures		206	19,748	95.86	18.12
Hay Meadows		111	18,755	168.96	17.21
Improved pastures		109	23,062	211.58	21.16
Unimp. pasture/range		61	8,541	140.02	7.84
Sub-total			**398,475**		**365.58**
Other Animal Injuries and Deaths. Including: horses, sheep, goats, swine, working dogs, pets of any type, food fowl, ratites, and other exotics.					
Sub-total			**203,583**		**186.77**
TOTAL Direct Reported Losses			**$3,400,557**		**$3,119.77**

[1] Total losses in category/number of respondents reporting losses in that category only.
[2] Total losses in category/total number of surveys with "Yes" response in any category (1,090).

REDUCING TREATMENT COSTS FOR FIRE ANT SUPPRESSION IN TEXAS CATTLE PRODUCTION SYSTEMS

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Treatment programs conducted to suppress populations of the red imported fire ant, ***Solenopsis invicta* Buren**, can be expensive and time consuming. Short of subsidizing the cost of fire ant insecticides by government programs, potential techniques for reducing treatment costs include: 1) develop economic injury levels and implementation of economic thresholds or action levels; 2) use modified treatment patterns; 3) reduce equipment requirements; 4) treat for ants while conducting other field operations such as fertilizing; and 5) adjust treatment timing to optimize residual effectiveness (i.e. fall broadcast insecticide bait applications provide suppression of fire ants during early spring months). Methods (2,3 and 4) were investigated in the trials reported below.

I. EVALUATION OF ALTERNATIVE RATES AND TREATMENT PATTERNS FOR RED IMPORTED FIRE ANT BAIT PRODUCTS, LOGIC[a] AND AMDRO®.

Previous studies (Drees et al. 1992; Drees et al. 1993) showed that the effects of a spot application of Logic[a] Fire Ant Bait (containing fenoxycarb, also sold as Award[a]) affect more than one fire ant mound. Broadcast application, applied as a "skip swath" pattern (0.75 lbs./acre), provided suppression of fire ant mound numbers similar to that obtained using conventional, full coverage (1.5 lbs./acre), treatment. In the trial reported in 1993, swaths were 35 ft. wide. In addition, the application of a 1.5 lbs. mixture of Amdro[a] Fire Ant Granules/Insecticidal Bait (hydramethylnon, 0.75 lbs. of formulation) plus Logic (0.75 lbs.) provided quick initial fire ant suppression, characteristic of the effects of an Amdro treatment, and long (over 1 year) suppression, characteristic of a Logic treatment. The trial reported here is a replication of this earlier study and included a spot treatment applied without a manual or electric seeder.

Materials and Methods

This trial was established behind the earthen dam at Granger Lake in Williamson County, Texas. This area is routinely mowed and has restricted access to U. S. Army Corps of engineers personnel, only. No livestock was grazed in this area and cut grass was not harvested for hay. Plots, 150 by 300 ft. (1.03 acres), were established with 30 ft. buffer areas. Active fire ant mounds were counted in each plot by using a 30 ft. long pole (made from 0.75 inch diameter PVC pipe reinforced internally with 0.5 inch electrical metal tubing (EMT)). This pole was carried by at least two people and walked lengthwise across 260 ft. of each plot on each side of the centerline (0.36 acre sample area). Active ant mounds were counted using the minimal disturbance method. Mounds were disturbed with a pointed stick and considered to be active when 25 or more worker ants emerged from the mound within 30 seconds.

Resulting ant mound counts were arrayed by plot and blocked into 4 blocks (replicates) of eight treatments each. Treatments (**Table 1**) were randomly assigned within each block. Full rate broadcast and strip treatments were applied using a tractor mounted Herd® Model GT-77 seeder, July 1, 1993. Reduced rate (0.75 lb./acre) Amdro and Logic broadcast applications were applied using a hand held Cyclone® Model 1C1 seeder, July 2. Periodically after treatments (4 weeks, 3 months, 6 months, 12 months and 18 months), fire ant mounds were monitored using the technique described above. Results were analyzed using analysis of variance (ANOVA)($P \leq 0.05$) and means were separated using Tukey's Studentized Range test.

Table 1. Treatments evaluated for red imported fire ant suppression, Granger Lake, Williamson Co., Texas, 1993.

Treatment	Pattern	Rate
1. Amdro® (hydramethylnon)	complete coverage broadcast	1.50 lbs./acre
2. Amdro® (hydramethylnon)	complete coverage broadcast	0.75 lb./acre
3. Logic® (fenoxycarb)	complete coverage broadcast	1.50 lbs./acre
4. Logic® (fenoxycarb)	complete coverage broadcast	0.75 lb./acre
5. Logic® (fenoxycarb)	skip swath broadcast	0.75 lb./acre
6. Logic® (fenoxycarb)	spot application	2 Tbsp./spot on a 30 by 30 ft. grid pattern (1.424 lbs./acre)
7. Logic® plus Amdro® (fenoxycarb plus hydramethylnon)	complete coverage broadcast	0.75 + 0.75 lb./acre
8. untreated control	---	---

Results

This site did not receive rain from 26 June 1993 until well into September. This dry weather suppressed ant mounding activity in all plots, including the untreated control plots (**Table 2**). The full Amdro and Amdro plus Logic treatments numerically reduced active ant mound numbers relative to other treatments by four weeks after treatment. However, significant differences between treatments did not occur until 3 months following treatment with all treatments except Amdro® having significantly fewer active ant mounds than untreated plots. Statistically, all Logic®-based treatments performed similarly throughout this trial. The mound numbers in Logic skip swath and spot treatment plots began to increase after 12 months and all treatments approached or exceeded pre-treatment levels after 18 months. Although results obtained from this trial were not as clear as those documented in the trial conducted at Lake Conroe Dam (Drees et al. 1993), the trends obtained from treatments remained the same.

Table 2. Number of active red imported fire ant mounds per 0.36 acre subplot and total ant mounds per treatment (for four replications) before and after treatment, Granger Lake, Williamson County, Texas, 1993.

	Mean no. active fire ant mounds/0.36 acre*					
TREATMENT	0 week	4 week	3 month	6 month	12 month	18 month
Untreated	57.75a	20.75a	20.00a	36.75a	50.00a	60.50a
Amdro, full rt	55.00a	7.00a	6.25abc	6.25b	24.75ab	61.50a
Amdro, half rt	56.75a	13.50a	15.5ab	25.25ab	35.25ab	74.50a
Amdro:Logic	55.00a	6.75a	1.50bc	2.00b	15.50b	49.25a
Logic, full rt	58.25a	13.50a	0.25c	2.50b	13.50b	67.25a
Logic, half rt	56.00a	17.50a	5.75abc	2.75b	14.50b	71.00a
Logic, skip	55.00a	19.75a	4.50bc	1.75b	16.75ab	61.25a
Logic, spot	54.75a	15.50a	4.25bc	1.25b	16.00ab	60.25a
F	29.49	4.19	4.11	4.66	2.74	0.96
P	0.0001	0.0028	0.0031	0.0015	0.0247	0.5003
R sq.	0.9335	0.6659	0.6620	0.6894	0.5662	0.3147
MSE	123.74	43.293	39.429	125.57	220.281	426.756
Crit. val.	4.743					
df	21					
Min. Sig. Dif.	26.383	15.605	14.843	26.577	35.201	48.995

* Means followed by the same letter(s) are not significantly different using analysis of variance and Tukey's Studentized Range Test ($P \leq 0.05$).

II. EVALUATION OF AMDRO® (HYDRAMETHYLNON) GRANULAR INSECTICIDE AND FERTILIZER FORMULATIONS FOR SUPPRESSION OF THE RED IMPORTED FIRE ANT.

This trial examined the efficacy of three formulations of **Amdro®** (hydramethylnon) Insecticide Bait blended with encapsulated fertilizer. Performance of these formulations were compared to **Amdro®** applied alone and applied simultaneously with urea fertilizer using separate applicators mounted and operated together on one tractor. Previous efforts have shown that mixing or blending fire ant bait products with fertilizer instantly reduces the attractiveness of the bait to the ant, but that bait applied simultaneously with fertilizer did not hinder ant foraging on bait particles.

Materials and Methods

This trial was conducted on pasture land on the Alex Gilstap and Bobby McGeehee Farms, Montgomery County, Texas. The test site is located along State Highway 105 in an area of clayey, blackland soil and consists of two pastures. The first pasture is a mix of improved and native grasses. The second, adjacent pasture is a mixture of planted switchgrass and kleingrass. Both pastures are moderately grazed throughout the year. Both pastures had fire ant mound densities of approximately 50 mounds per acre. That and the large size of both the ants and the mounds indicate a monogyne infestation.

Six test plots were marked and pre-counts taken on 10 June 1994. Plots consisted of 5 rectangles 450 ft. by 150 ft. or 1.55 acres or larger. Due to application considerations and a limited amount of treatment material, only one large plot was marked for each treatment. Within these treatment areas, three pieces of rebar were evenly spaced as sample subplot centers. Subplot samples consisted of a 58 foot circle encompassing 0.25 acres. The number of active red imported fire ant mounds were counted and recorded within each subplot area before and periodically after treatment (5 July, 20 July and 3 Oct. 1994). Mounds were considered active if numerous ants emerged from the mound upon minimal disturbance. Colony vigor was rated during post-treatment evaluations using a rating scale of 0 to 3, with 0 = no ants; 1 = 1 - 100 ants; 2 = 101 - 1,000 ants; 3 $\geq$ 1,001 ants. Subplot data were analyzed using analysis of variance (ANOVA) and means separated using Tukey's Studentized Range test ($P \leq 0.05$).

On 14 June, treatments (Table 3) were applied using tractor mounted equipment. All fertilizer plus **Amdro®** treatments were applied using a PTO-operated Crop Spreader fertilizer applicator with a rotary-type agitator (setting 13). **Amdro®**, applied alone or simultaneously with urea was applied with an electric Herd GT-77 Seeder calibrated to apply 1.5 lbs. formulation per acre, and mounted on top of the Crop Spreader (Fig. 1). Treatments were applied between 5:15 and 7:15 pm. Ground was dry at time of application. Light rain was reported the evening before application, and rain was in the area during the middle of the night after treatments.

Results

The number of fire ant mounds initially present in each subplot was very similar between treatment plots: 1) Untreated - 10,9,9 2) Amdro® - 12,11,14
3) Pursell - 15,14,18 4) Lessco - 8,13,16
5) Scott's - 10,11,17 6) Urea + Amdro - 9,13,14

None of the microencapsulated fertilizer plus Amdro® formulations reduced fire ant mound numbers or activity rating relative to the untreated plots (**Table 4**). Of the fertilizer blends evaluated, the J. M. Scott's & Sons, Inc. blend numerically outperformed other formulations.

Amdro applied alone significantly reduced ant activity ratings from 2 to week 4, while Amdro applied simultaneously with fertilizer significantly reduced both active mound numbers as well as activity throughout this 16 week trial, providing a 96 to 97 percent reduction in active mound numbers relative to untreated subplots. More effort to develop fertilizer plus Amdro® may result in an efficacious formulation. Fertilizer, applied simultaneously with Amdro® Insecticide Bait performed well and may be a useful treatment method for both urban and agricultural operations. Additional field trials will provide documentation for these treatments and treatment methods. In future work, a treatment using fertilizer (i.e., urea) alone should be added to determine if fertilizer suppresses fire ant mound numbers.

Conclusions

Results of trials reported here provide documentation for methods designed to reduce fire ant treatment costs. With little or no reduction in product performance, Logic® (fenoxycarb) spot treatments can suppress ants without the need for application equipment, and strip or skip-swath treatments can cut product and labor (time) costs in half. These alternative treatment methods should be considered by the manufacturer as additions or modifications to existing product labels.

Amdro® Insecticide Bait (hydramethylnon) continues to be the fastest acting conventionally formulated fire ant bait treatment. Simultaneous application of Amdro® while fertilizing pastures can reduce treatment costs, although two applicators must be mounted and calibrated on a single tractor and thorough coverage by both materials is necessary. Blending Logic® and Amdro® and applying the mixture at half rates of each product continues to provide a product performance profile that appears to offer both a quick suppression of ant mound numbers (characteristic of Amdro®) as well as long residual activity (characteristic of Logic®).

Results generated from these applied research trials do not constitute a recommendation for use of these practices by the Texas Agricultural Extension Service or the Texas Agricultural Experiment Station.

Table 3. Treatments and rates evaluated for suppression of red imported fire ant mound numbers, Montgomery County, Texas, 1994.

Treatment		Rate
1.	Pursell Industries (LaRoche) 33-0-11 Mini plus Amdro® (green & yellow) 125 lbs/acre = 1.5 lbs. Amdro	188 lbs./1.5 acres
2.	Lessco Poly Plus 35-0-0 plus Amdro® (yellow) 150 lbs./acre = 1.5 lbs. Amdro	225 lbs./1.5 acres
3.	J.M. Scott & Sons, Inc. S-6012, Ext. No. 4-138-1CW plus Amdro® (orange) 103 lbs./acre = 1.5 lbs. Amdro®	150 lbs./1.5 acres
4.	Amdro (1.5 lbs./acre), fertilizer Urea 45-0-0 (white) (300 lbs./acre = 65 lbs. N) Amdro® 3.2 lbs.*	600 lbs./2.2 acres
5.	Amdro® (1.5 lbs./acre)**	2.25 lbs./1.5 acres
6.	Untreated control**	1.5 acres

* (Note: due to space limitations, this plot was placed in a treated area in the shape of a triangle with two 450 feet sides for an area of 2.21 acres.)

** These two plots were located in an adjacent (across the fence) switchgrass field.

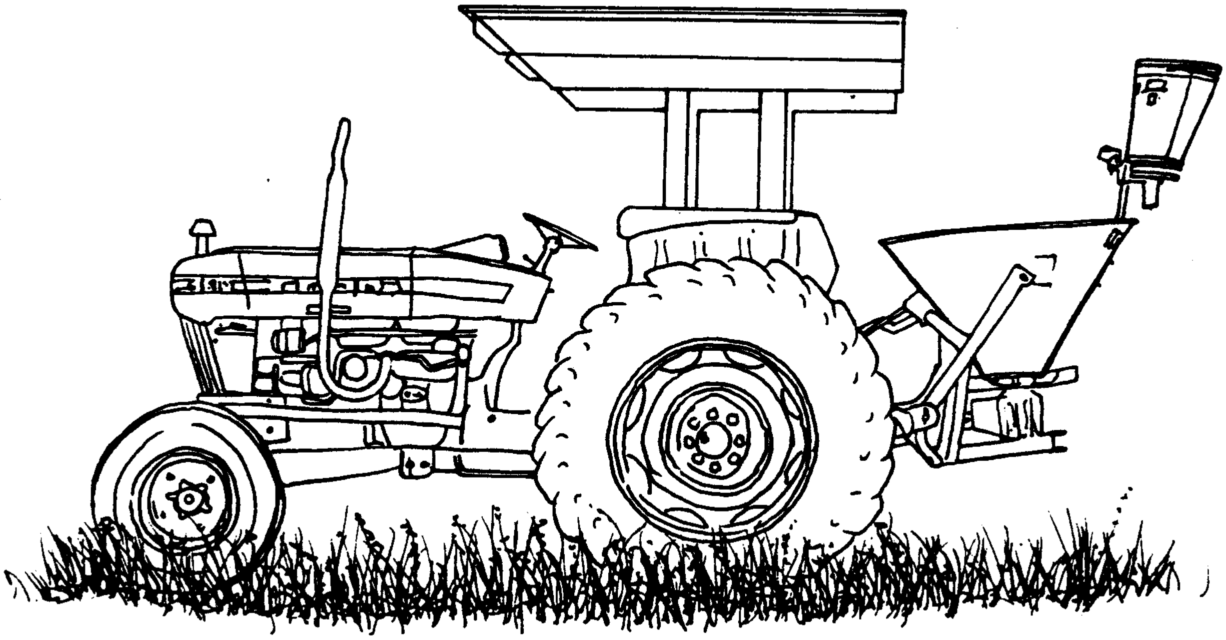
Table 4. Mean number of active red imported fire ant mounds and average activity rating per 0.25-acre circular subplot (n = 3), Dobbin, Texas, 1994.

	Weeks following treatment		
	2 weeks	4 weeks	6 weeks
Treatment	Mean no. mounds*		
Untreated control	9.33 ab	9.00 ab	10.00 ab
Amdro® (1.5 lbs./acre)	6.67 b	2.67 bc	3.33 bc
Pursell Industries + Amdro®	11.00 a	10.67 a	11.00 a
Lessco Poly Plus + Amdro®	9.67 ab	9.00 ab	8.33 ab
J.M. Scott's & Sons, Inc.	7.33 ab	5.67 abc	4.00 abc
Urea (300 lbs) + Amdro® (1.5 lbs./acre)	0.33 c	0.33 c	0.33 c
F-value	11.43	7.14	5.41
P	0.0005	0.0031	0.0087
MSE	2.8556	5.0556	7.2000
MSD	4.7922	60.764	7.6096
df	10		
Crit. Val.	4.912		

Treatment	Rating*		
Untreated control	25.33 ab	26.33 a	28.00 ab
Amdro® (1.5 lbs./acre)	10.00 cd	6.67 b	8.00 bc
Pursell Industries + Amdro®	32.00 a	29.67 a	30.67 a
Lessco Poly Plus + Amdro®	26.33 ab	25.33 a	23.33 ab
J.M. Scott's & Sons, Inc.	19.00 bc	14.00 ab	9.33 abc
Urea (300 lbs) + Amdro® (1.5 lbs./acre)	0.67 d	1.00 b	0.67 c
F-value	15.37	9.15	5.50
P	0.0001	0.0012	0.0082
MSE	19.2889	32.5667	59.8333
MSD	12.455	16.184	21.936
df	10		
Crit. Val.	4.912		

* Means followed by the same letter are not significantly different using analysis of variance (ANOVA) and means separated using Tukey's Studentized Range Test ($P \leq 0.05$). Colony vigor was rated during post-treatment evaluations using a scale of 0 to 3, with 0 = no ants; 1 = 1 - 100 ants; 2 = 101 - 1,000 ants; 3 $\geq$ 1,001 ants. Rating indicates mean total per subplot.

Figure 1. Tractor mounted PTO-operated Crop Spreader fertilizer applicator with an electric Herd® GT-77 Seeder mounted on top, used to apply 1.5 lbs. per acre Amdro® simultaneously with 300 lbs./acre urea (45-0-0).



Acknowledgements

We are grateful to Chris Sansone and cotton field scouts for assisting with the 4 week post-treatment evaluation of the Granger Lake trial. Funding for these trials was provided by Ciba-Geigy Corporation and American Cyanamid. We also wish to thank the U.S. Army Corps of Engineers staff at Granger Lake, and to Alex Gilstap and Bobby McGeehee Farms, Montgomery County, Texas for allowing use to conduct these trials on these sites.

Literature cited

Drees, B. M., C. L. Barr and S. B. Vinson. 1992. Effects of spot treatments of Logic® (fenoxycarb) on polygynous red imported fire ants: an indication of resource sharing? Southwestern Entomol. 17(4):313-317.

Drees, B. M., C. L. Barr and M. E. Heimer. 1993. Skip-swath application of Amdro® and Logic® for the suppression of the red imported fire ant *in* Proceedings of the 1993 Imported Fire Ant Research Conference (ed. J. P. Ellis), Charleston, South Carolina.

FIRE ANT ECONOMIC IMPACT: EXTENDING ARKANSAS' SURVEY RESULTS OVER THE SOUTH

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Summary

Losses to fire ants can be conveniently grouped into three main categories: 1) damage caused by fire ant activity, 2) medical disbursements induced by stings, and 3) pesticide expenses incurred trying to reduce the first two losses. Although fire ant deprivations are imposed on public, business, and private activities, damages inflicted on private activities are perhaps easier to measure. Damage to business enterprises are often unavailable due to proprietary concerns and damage to public enterprises are difficult to acquire due to the various levels within bureaucracies that make data acquisition difficult. Thus, fire ant damage is most easily acquired from private enterprises, since they are typically small enough to quickly access needed information. Thus, this economic assessment analyzed this last group.

Households are a convenient unit for gathering information since they are commonly used by the U.S. Census Bureau to calculate and report many kinds of statistics, and they are unitless (i.e., unit area measurements like square feet or acres are not employed).

A mail survey was conducted in September of 1993 to assess the economic impact of fire ants in southern Arkansas. Residents were selected for participation by having the Cooperative Extension Service in Bradley, Drew and Miller Counties provide us with names of persons on their mailing lists (duplicates were removed). These counties were selected because they are representative of southern Arkansas, they have plenty of fire ants, and their residents are enthusiastically interested in fire ant control. Of 1250 questionnaires mailed, 325 (26%) were returned, with almost equal numbers from each county. The questionnaire requested information on economic questions. Inquiries were made about:

- the area, times treated, and costs of current fire ant control efforts;
- costs of medical treatment for fire ant stings;
- nature of fire ant losses and dollar losses;
- nature of fire ant benefits and dollar benefits.

The 26% response rate to our survey could introduce bias into our results if those responding are not representative of the entire population of households. Also, because of the range of responses to our open-ended monetary questions there is considerable variation associated our mean values (e.g., total losses caused by fire ant induced damage ranged

from \$0 to \$7,000 per household, and averaged \$175, with a standard error of ± 37). Therefore, 95% confidence limits are likely to be wider than normal. To make the summary information presented here easier to comprehend, only means are used.

Based on our 1993 survey, mean total losses to fire ants for the damage, medical and insecticide categories was \$265/household. To remove some of the bias associated with differences in the nature of the landholdings in urban vs rural locals, results were stratified into urban and rural households (unfortunately, one question we failed to ask was whether respondents resided in an incorporated community). This was accomplished indirectly by classifying households that owned 1 acre of land or less as urban (51 of 325 households or 16%). Households owning more than 1 acre of land were classified as rural (274 households or 84%). Mean total losses for urban and rural households were:

	Mean ± (standard error)	
	Urban Losses	Rural Losses
Medical	1.60 (1.60)	0.85 (0.35)
Pesticides	48.20 (9.90)	96.40 (10.70)
Damage	37.30 (17.40)	200.70 (43.20)
Total	87.10 (22.40)	298.00 (46.70)

Projecting Arkansas' total losses over all households within infested counties in nine heavily infested southern states (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Texas) showed total losses of \$2.77 billion annually (14 million urban households x \$87/household + 4.9 million rural households x \$298/household). Application of pesticides for all uses reached \$1.1 billion annually (14 million urban households x \$48/household + 4.9 million rural households x \$96/household). Application of pesticides just to yards reached \$872 million annually (18.968 million households x \$46/household). A 1991 EPA National Home and Garden Pesticide Use Survey suggested that about 40% of all southern households treated for fire ants. In this case, our pesticide expenses would have to be multiplied by 0.4. In either case, total losses to fire ant are in excess of \$1 billion dollars annually. This is a substantial amount.

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CONSUMER EVALUATION OF THE TWO-STEP METHOD FOR FIRE ANT CONTROL

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Fire ants rank as one of the most widespread and important urban insect pest problems in Texas. Consumer demand for a simplified explanation of how to control fire ants in urban residential areas led to development the Two-Step Method for fire ant control (Merchant and Drees, 1992). The Two-Step method consists of (Step One) a broadcast bait application, followed by (Step Two) individual mound treatments of troublesome mounds or mounds in high-traffic areas. While the individual components of the Two-Step Method have been evaluated over several years and proven effective, the overall approach has not been evaluated. The purpose of this study was to assess the Two-Step Method using subjective evaluations by users of the method.

Materials and Methods

Hour-long presentations on how to use the Two-Step Method to control fire ants were made in six counties during April and May, 1993 and in two counties (Grayson and Taylor) during April, 1994. Programs were open to the public and emphasized a message that fire ants can be successfully controlled. An Extension Service fact sheet on the Two-Step Method (Merchant and Drees, 1992) was distributed during each meeting, and persons interested in participating in a home demonstration were solicited at this time.

Criteria for participating in the test were: (1) participants had not previously used fire ant baits as broadcast treatments for fire ants; (2) participants would follow the Two-Step Method for at least one summer; and (3) participants would be willing to fill out a follow-up survey at the end of the fire ant season.

Each volunteer was requested to fill out an application form (pre-survey) which asked several questions about previous experience with fire ant control and their satisfaction with the methods they had been using. In return, each volunteer received a one pound container of fire ant bait (Amdro® or Logic®) and a one pound container of an individual mound treatment, either Ortho Fire Ant Killer Granules (5% diazinon) or Ortho Orthene® Fire Ant Killer (75% acephate dust).

A second, follow-up survey (post-survey) was distributed to volunteers during November and December, 1993 and 1994. Surveys were collected during December and January, and results were entered into a computer for analysis.

Table 1. Numbers of volunteer participants in evaluation of Two-Step Method for fire ant control, by county. Texas, 1993-1994.

County	No. Participants Completing Applications	No. Follow-up Surveys Completed
Dallas	8	4
Denton	28	17
Fannin	18	10
Grayson	25	16
Kauffman	27	25
Rockwall	11	11
Tarrant	6	6
Taylor	13	13
Totals	136	102

Results

One hundred and thirty-six volunteers indicated their willingness to participate in the study by completing the pre-survey (Table 1). Of these, 102 participants completed the post-survey, and 92 were able to try the Two-Step Method for one season.

Prior to trying the Two-Step Method, 91.8% (n=111) of the respondents rated their fire ant problem as moderate to severe. The most popular treatments among pre-survey respondents were, in order of preference, granular insecticides (35.4%), baits applied as mound treatments (28.1%), and dusts (25.0%)(n=96). Liquid mound treatments were used by only 1% of the participants. Thirty-six percent of the participants had never used a bait product before the training (n=119). Of those who had used baits previously, Amdro® was used by 89.6%, Logic® (or Award®) by 15.6%, and Prodrone® by 2.6% (n=77).

The follow-up survey completed at the end of the fire ant season indicated that there were significant differences in satisfaction level between participants before and after following the Two-Step Method for one season (χ^2 test, $P<0.01$). More post-survey respondents indicated they were satisfied or very satisfied with their ability to control fire ants compared to pre-survey respondents (Fig. 1). More than 71% of post-survey respondents said they were satisfied or very satisfied with the control provided by the method, compared with only 15.7% of the respondents to the pre-survey. Nearly 80% of the respondents said they obtained better control using the Two-Step Method compared to methods they had used in the past (Table 2). Nearly 87% of the participants who used the Two-Step Method planned to continue it next year, 12% didn't know, and

Figure 1. Level of satisfaction with fire ant control methods among volunteers before (pre-survey) and after (post-survey) a one season trial of the Two-Step Method of fire ant control. Texas, 1993-1994.

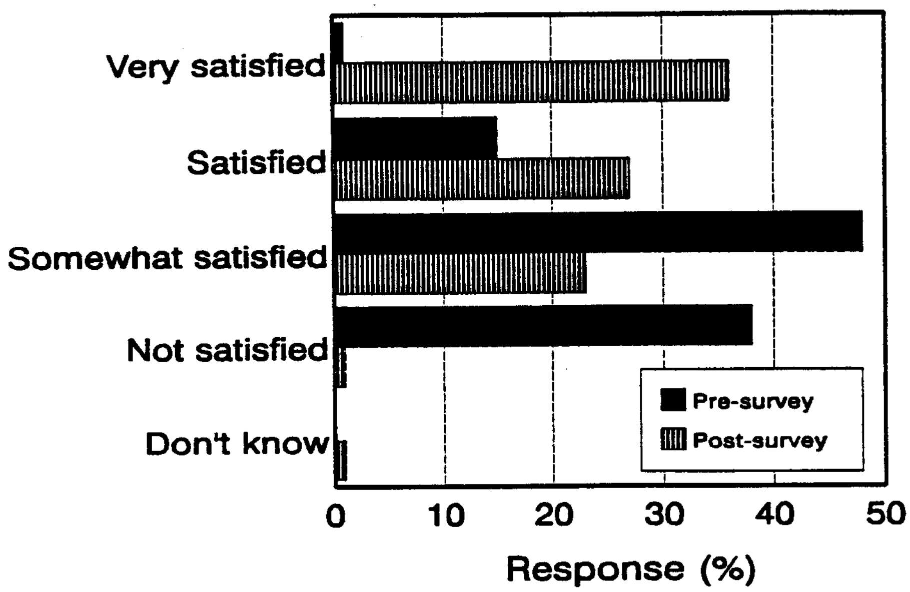

Table 2. Volunteer perceptions of fire ant control using the Two-Step Method compared to methods used in the past. Texas, 1993-1994.

Response	Frequency	Percent	Cumulative Percent
Much better	51	57.3	57.3
Slightly better	20	22.5	79.8
About the same	12	13.5	93.3
Slightly worse	1	1.1	94.4
Don't know	5	5.6	100.0

only one person said they would not use the method next year (n=91).

Seventy-one percent of the participants using Amdro® (n=60) were satisfied or very satisfied with the level of fire ant control compared to 62% using Logic® (n=16); however there was no significant difference between these two groups (χ^2 test, $P>0.05$). There appeared to be no relationship between the size of the area treated by participants and satisfaction with the method.

Participants in the study gave the Extension Service fact sheet on the Two-Step Method high marks. Nearly 90% agreed that brochure was understandable, 95% agreed it provided useful information, and nearly 85% agreed with the statement that the publication taught them things they did not previously know about fire ant control.

Conclusions

The use of broadcast bait applications for fire ant control provides several advantages to consumers, including lower cost, enhanced safety, and a higher degree of effectiveness. The Two-Step Method, based on broadcast bait applications, provided a higher degree of satisfaction to consumers than had been obtained with other methods, primarily individual mound treatments; and most participants trying the method anticipated that they would continue to use the program next year. For this reason, the Two-Step Method appears to be a viable tool for encouraging the adoption of broadcast fire ant bait treatments among consumers.

The training program and demonstration were well received by participating county Extension agents as a means for educating clientele about better methods for fire ant control. Further study is required to determine whether use of home demonstrations can effectively increase the rate of adoption of broadcast bait application among consumers.

Acknowledgements

County Extension agents Mark Arnold, Gary Bomar, John Cooper, Jan Cox, Michael Lee, Stacy Reese, Curtis Thompson, and Tim Trimble set up the training meetings and coordinated collection of the follow-up surveys. Special thanks are extended to Ciba Corporation, American Cyanamid, and Ortho Consumer Products for providing fire ant control materials for distribution to the volunteers in this study.

Reference Cited

Merchant, M.E. and B.M. Drees. 1992. The Two-Step Method: Do-it-yourself Fire Ant Control. Texas Agricultural Extension Service Leaflet L-5070.

CAN A ONE-TWO PUNCH OF LOGIC®-ORTHENE® BE USED TO ERADICATE FIRE ANTS?

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Abstract.

A single broadcast application of fenoxycarb (Logic®/Award®) bait, followed one week later by acephate (Orthene®) mound treatments successfully eradicated imported fire ants in three of four locations (Arkansas, Oklahoma and Tennessee) north of the federal quarantine line. Implications for this eradication strategy are discussed.

Introduction

During their range expansion, imported fire ants (IFA) (Solenopsis *invicta* Buren and/or *Solenopsis richteri* Forel) have *appeared* in numerous isolated areas ahead of the general infestation. To slow migration, it has been necessary to eradicate these isolated infestations before they become well established. Coping with this problem demands an eradication method that is effective, yet not labor intensive nor cost prohibitive.

Research has shown that a two-step method is effective at controlling fire ants (Texas Agricultural Extension Service Leaflet 1992). We took this idea one step further to determine if fire ants could be eradicated using this procedure.

Materials and Methods

The first step of the two-step method is to broadcast the infested area with a commercially available fire ant bait. We chose Logic®/Award® (fenoxycarb) because at the 1% concentration it is a repellant to many native ants (Reimer and Beardsley 1990, Williams and Vail 1993). These repellent properties lower possible impacts on native ant populations (Zakharov and Thompson, unpublished data). Maintaining native ants is important because they increase mortality of founding queens (Apperson et. al. 1984). Fenoxycarb acts as an insect growth regulator and does not actually kill ants, but interferes with reproduction. Most queens cease egg production and the brood is altered to develop into reproductives (Banks et. al. 1978). Because fenoxycarb is not a poison, worker ants must die of natural causes, therefore noticeable fire ant control takes 4-6 weeks.

The second step includes treating individual mounds with a contact insecticide. Orthene® (acephate) was chosen because many states currently use it in their eradication programs. Acephate, while not completely effective at eradicating colonies of fire ants, will accelerate the demise of workers and brood.

Study sites were recruited with help from the Arkansas State Plant Board, the Oklahoma Department of Agriculture, and the Tennessee Department of Agriculture. Desirable sites had to be located at least 25 km north of the federal imported fire ant quarantine line for Arkansas, Oklahoma, and Tennessee. Sites were selected if the infested area was less than 3 ha in size. Ultimately, one trial was located at McAlester, OK, another at Bryant, AR and two at Memphis, TN. The sites were:

Key Tractor Sales, McAlester, OK. A tractor dealership on highway 69 bypass in the southeastern section of the city. IFA were located in grassy islands around the repair buildings and along a boundary of the Union Stockyards parking lot to the southwest of the dealership. Fifteen IFA mounds were found on the property when first surveyed on July 21, 1994.

Bryant Shopping Center, Bryant, AR. A shopping center located south of I-30 just southwest of Little Rock. IFA were located in a grassy field between parking lots of the shopping center and a video store to the south of the shopping center. Most mounds were located along the I-30 service road. A total of 29 IFA mounds were located during our initial survey on July 19, 1994.

McDonald's Restaurant, Memphis, TN. A restaurant located on northeast corner of Gleneagles Shopping Center on Shelby Drive in eastern Memphis. Three IFA mounds were found in the landscape planter island between McDonald's and Shelby Drive during our initial survey on August 2, 1994.

Super 8 Motel, Memphis, TN. A motel on south side of I-40 service road in eastern Memphis. IFA were found around outer edges of parking lot that surrounds the motel. Five IFA mounds were located during our initial survey on August 2, 1994.

Ant populations at each site were sampled using sugar bait stations placed approximately 10 m apart in a grid pattern. Bait stations extended a minimum of 40 m past known IFA mounds. Barriers, such as paved parking lots, buildings and bodies of water, would necessitate ending a bait line. Each bait station consisted of a small wad of cotton soaked in a 10% sugar-water solution placed in the middle of a white plastic vial lid. These bait stations were placed flat on the ground and allowed to attract ants for a minimum of one hour. During this hour a map was drawn of each site and active fire ant mounds were plotted. Each mound was disturbed by poking with a rod to determine if the mound was active. Ants were collected by snapping a plastic vial over the ants at each bait station. Vials were brought back to the laboratory and placed in a freezer overnight to kill the ants. The next day ants were fixed in 80% alcohol and identified. Following ant identification, extent of the IFA infestation could then be mapped.

When ant sampling was complete, fenoxycarb fire ant bait was broadcast over the infested area using a Herd Model GT-77 Bait Spreader mounted on the back of a Polaris 350 ATV. The spreader was calibrated to deliver 1.7 kg of bait per hectare when driven 13 km per hour across the area to be treated on swaths spaced 7 m apart. Bait was applied approximately 40 m beyond the infested area wherever possible.

One week later, approximately 45 cc of acephate was sprinkled over each IFA mound to kill worker ants. Waiting one week before treating with acephate allowed worker ants to gather the fenoxycarb bait and feed it to other members of the colony.

Each site was visited monthly until November. Final sampling was made in late March and early April 1995, because fire ants are inactive during the winter months of December - February. Our standardized sampling procedures were repeated each month and maps were drawn to indicate IFA presence for both mounds and IFA collected at bait stations.

Results

As expected, fire ants decreased noticeably in the months after insecticide applications (Table 1). Fire ants were eliminated at Key Tractor by the second monthly post-treatment count and remained absent for the remainder of the test. The two Memphis, TN sites continued to have fire ants for several months, but by the last visit in April, fire ants had disappeared. Fire ants were not eradicated from the Bryant, AR shopping center. Although the overall numbers of fire ants dropped noticeably for the 1994 counts, the April count found several colonies on the rebound.

Discussion

Eradication of small isolated populations of IFA using only one sequential application of fenoxycarb and acephate shows promise. The Bryant, AR site had only partial success. This could be due to many factors. Fire ant populations are in a constant state of change. When a mound is disturbed, the ants sometimes move their colony (Lofgren et. al. 1975). Perhaps after the fenoxycarb treatment several IFA colonies moved and weren't detected when the acephate was applied. Because of the larger size of this infestation and the larger number of ant mounds, this might be more likely to happen than at the sites with only a few fire ant mounds.

Another possibility is that a nuptial flight occurred prior to the treatment at Bryant and new IFA queens had established themselves. Because fire ants do not begin foraging for a while after a new colony is started, the insecticide treatments may not have been picked up. Since new colonies are very small, they may not have been spotted and missed the acephate treatment. Whatever the reason, a second "One-Two" application probably would have completed the eradication process.

Failure to eradicate ants at the Bryant, AR may demonstrate that several retreatments should be made for larger IFA infestations. Success of the other three sites show that eradication of IFA is possible with this two-step method.

Acknowledgments

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Literature Cited

Apperson, C.S., R.B. Leidy and E.E. Powell. 1984. Effects of Amdro on the red imported fire ant (Hymenoptera: Formicidae) and some nontarget ant species and persistence of Amdro on a pasture habitat in North Carolina. J. Econ. Entomol. 77: 1012-1018.

Banks, W.A., C.S. Lofgren, and J.K. Plumley. 1978. Red imported fire ants: effects of insect growth regulators on cast formation and colony growth and survival. J. Econ. Entomol. 71: 75-78.

Lofgren, C.S., W.A. Banks and B.M. Glancey. 1975. Biology and control of imported fire ants. Ann. Rev. Entomol. 20: 1-30.

Reimer, N.J., and W. Beardsley, Jr. 1990. Effectiveness of hydramethylnon and fenoxycarb for control of bigheaded ant (Hymenoptera: Formicidae), an ant associated with mealybug wilt

of pineapple in Hawaii. J. Econ. Entomol. 83: 74-80.
Texas Agricultural Extension Service. 1992. The two-step method: do-it-yourself fire ant control. Texas Agricultural Extension Service Leaflet No. L-5070. College Station, TX.
Williams, D.F., and K.M. Vail. 1993. Pharoh ant (Hymenoptera: Formicidae): fenoxycarb baits affect colony development. J. Econ. Entomol. 86: 1136-1143.

Table 1. Number of bait stations with fire ants and (active IFA mounds) during the two-step eradication test.

Site	July	August	September	October	April
Key Tractor	18 (15)	1 (0)	0 (0)	0 (0)	0 (0)
McDonalds	6 (3)	1 (2)	4 (2)	1 (0)	0 (0)
Motel	2 (5)	1 (2)	1 (2)	0 (1)	0 (0)
Bryant	20 (29)	4 (30)	2 (3)	5 (3)	3 (7)

SUBSURFACE INJECTION OF SOIL INSECTICIDES FOR CONTROL OF IFA: EMERGING TECHNOLOGY OR MERELY A FLASH IN THE PAN?

Homer Collins, Anne-Harie Callcott and Avel Ladner [1]

INTRODUCTION: suSCon Green®, a controlled release formulation of chlorpyrifos produced by Incitec Ltd., Brisbane, Australia provides multi-year control of several species of white grubs when applied in furrow in sugarcane (May and Boehm 1986). Season-long control of imported fire ants has been achieved at rates of 3 to 5 lbs AI per acre when suSCon Green was applied as a broadcast surface treatment to grass sod (Collins & Callcott 1993, Callcott & Collins 1995). However, surface applications of suSCon Green, and other pesticides, are susceptible to UV and other forms of chemical degradation. Subsurface placement of pesticides theoretically result in several benefits, including reduction in the amount of pesticide required to control the target pest, reduced surface residues, reduced potential for run-off, reduced drift, and possibly extended residual activity. Niemczyk (1993) reviewed subsurface placement of pesticides and concluded that this technology is worthy of increased and continued consideration. Studies to date with subsurface placement of pesticides have concentrated on control of white grubs and mole crickets in golf course fairways and athletic fields. Fire ant control with this relatively new technology has not been investigated.

We initiated a study in April 1994 to compare efficacy of surface versus

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subsurface applications of suSCon Green to determine the potential of this technology as a quarantine treatment for commercial grass sod.

<u>MATERIALS AND METHODS:</u> A granular slit applicator (subsurface applicator) manufactured by Canaan Industries, Dothan, AL, was used to place suSCon Green at a depth of approximately 0.75 inches beneath the soil surface in a non-production field of Tifway 419 grass sod on April 5, 1994. Surface applications of suSCon Green were applied with a Herd® granular applicator (Model GT-77) mounted on a Suziki ATV. Application rates were 4 lb AI per acre (40 lbs of formulated product) for both treatments. Prior to pesticide application, 1-acre test plots were established on the Eric Green turf farm near Dothan, AL. IFA population estimates were made in the center of each 1-acre plot using both total colony counts and the population indexing system described by Harlan et al. (1981), and later modified by Lofgren and Williams (1982). Each treatment, including untreated check plots, was replicated 4 times. Posttreatment ratings of each test plot were conducted at 6 to 12 week intervals to evaluate the effect of each treatment on the IFA population. Normal agricultural practices including mowing, fertilization, etc. continued as usual throughout the course of this study. However, irrigation was not used at any time. Treatment means for each posttreatment rating interval were statistically analyzed using ANOVA and Tukey's Test.

<u>RESULTS:</u> The fire ant population in our test plots ant averaged 55.7 nests per acre prior to application. Both surface broadcast applications and subsurface placement of suSCon Green provided greater than 95% control of IFA at 6, 12, 18, 26, and 40 weeks post-application (Table 1). By 52 weeks

postreatment control in the surface broadcast plots had declined to 87.0%, which was not statistically different from the 98.8% seen in the subsurface plots. These results suggest that subsurface placement of suSCon Green at a rate of 4 lbs AI per acre does effectively control fire ants. Additional evaluations will continue to determine if residual activity is extended by subsurface placement. Current cost estimates for the equipment (approximately $27,000 for the Canaan Applicator), may preclude use of this technology as a quarantine treatment for grass sod unless multi-year control of IFA is achieved. The length and level of control achieved by surface applications of suSCon Green make this product an excellent candidate for use in the quarantine program. However, suSCon Green is not yet registered for this use pattern.

Table 1. Control of Imported Fire Ants with Surface Broadcast and Subsurface Applications of suSCon Green. Dothan, AL. 1994.

Insecticide	Avg. % Chg. in Pretreat Pop. Index@ indicated Wks Posttreat †					
Placement	(6)	(12)	(18)	(26)	(40)	(52)
Surface	-95.9a	-97.7a	-100a	-95.3a	-97.0a	-87.0a
Subsurface	-99.6a	-99.7a	-100a	-99.2a	-97.8a	-98.8a
Untreated CK	-17.5b	-14.5b	-46.5b	-10.5b	-17.0b	+51.2b

† Mean based on 4 replicates per treatment. Means within a column followed by the same letter are not significantly different at the 5% level using Tukey's test.

ACKNOWLEDGEMENTS: The Canaan Granular Applicator used in these trials was provided by Steve Strickland, Canaan Industries, Dothan, AL. The suSCon Green was furnished by Peter May, Incitec, Ltd. Brisbane, Australia. Eric Green, Greens Turf Farm, Dothan, AL allowed us to use part of his farm for our tests. Our thanks go to Randy Cuevas, Tim Lockley, Lee McAnally, and Kirk Irby for their help in treating and evaluating test plots.

REFERENCES CITED:

Callcott, A.-M. & H. L. Collins. 1995. RIFA quarantine treatments in commercial grass sod, 1993. Arthropod Manage. Tests 20: (In press).

Collins, H. L., & A.-M. Callcott. 1993. RIFA quarantine treatments in commercial grass sod, 1992. Insect. & Acaric. Tests. 18:333.

Harlan, D. P., W. A. Banks, H. L. Collins, and C. E. Stringer. 1981. Large area tests of AC-217,300 bait for control of imported fire ants in Alabama, Louisiana, and Texas. Southwest Entomol. 6: 150-157.

Lofgren, C. S., and D. F. Williams. 1982. Avermectin B_1a, a highly potent inhibitor of reproduction by queens of the red imported fire ant. J. Econ. Entomol. 75: 798-803.

Niemczyk, H. D. 1993. Subsurface placement of pesticides and other materials: perspective. *In:* R. N. Carrow, N. E. Christians & R. C. Shearman [eds.]. International Turfgrass Society Research Journal 7. Intertec Publishing Corp. Overland Park, Kansas.

May, P. D., & Nina Boehm. 1986. Controlled release soil insecticides for control of sugar cane pests. Sugar y Azucar. July/August 1986, pp 127-132.

HAVE WE "MAXED-OUT" ON FIRE ANT CONTROL WITH BAITS?

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Summary

To investigate efficacy of insecticide baits at reducing red imported fire ant (*Solenopsis invicta* Buren) populations, 54 treatment sites in southeastern Arkansas were monitored. Check and treatment plots (>0.4 ha) were established at each site using twice-yearly (June and October) broadcast applications of hydramethylnon (Amdro®) and fenoxycarb (Award/Logic®) baits applied at a rate of 0.68 kg/ha of formulated bait. Mounds were counted monthly within 0.1 ha subplots (excluding winter months when ants were inactive). Colonies were placed into five size classes: 1-100; 101-1,000; 1,001-10,000; 10,001-50,000; and 50,001-220,000 worker ants. Two other traits were estimated: mound density (per 0.1 ha) and total percentage coverage of colony foraging territories in plots. Total coverage was calculated using the relationship between number of workers (N) and colony territory (S, m^2): $S = 0.00067$ N. Computed values for mound density and territory coverage were averaged over the period July 1992 to June 1993 (excluding December, January and February) producing a new variable called active period average (APA) for each. These APA values for check and bait plots were averaged spatially as well and used for practical assessment of bait efficacy. Mound density over all check plots was 26.0 (± 3.3 s.e.) mounds per 0.1 ha, and territory coverage was 21.5% (± 3.3% s.e.). Estimated efficacy of baits in reducing mound density was 80%, and for territory coverage it was 84%; there were no differences between baits. Therefore, applied twice per year, these baits were effective. A proposed mathematical model of fire ant dynamics with 100% suppression of the population twice a year produced a theoretical maximum reduction in mound density of 90%. Since the 80% reductions achieved in field experiments are close to calculated theoretical upper limit of 90%, twice-yearly applications of baits for controlling S. invicta populations appear to be reaching their maximum potential.

This research was funded in part by USDA APHIS grants 92-8100-0229-GR and 94-8100-0229-GR to LCT, and the results do not necessarily express APHIS' views. Published with permission of the Director, Arkansas Agricultural Experiment Station, Fayetteville.

EFFECT OF ALTERNATIVE BAIT FORMULATIONS ON IMPORTED FIRE ANTS AND NON-TARGET ANT POPULATIONS

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Summary

To examine the potential of reducing the impact of imported fire ant baits on other ant species, ant populations were monitored after field applications, to 1 acre plots, of alternative bait formulations in 1993 and 1994. In 1993, Caribbean fruit fly, *Anastrepha suspensa*, pupae were soaked in 12% fenoxycarb, pyriproxyfen, or sulflurarnid, dissolved in acetone. In 1994, pregel defatted corn grit was soaked in either a 1.25% fenoxycarb or hydramethylnon acetone solution resulting in a corn grit bait without a supplemental oil attractant. In addition, imported fire ant baits that contained the traditional soybean oil based attractant were applied. The efficacy of the baits against imported fire ants, *Solenopsis invicta*, was assessed by population index (Lofgren and Williams 1982, J. Econ. Entomol. 75: 798-803). Non-target ant populations were monitored by pitfall traps set for 24 hours and determining the percentage of non-*S. invicta* ants trapped from 1/2 acre circular monitoring plots. Populations were monitored at 4, 8, and 12 weeks after treatment in 1993 and at 4.5, 8, and 17 weeks in 1994.

For the 1993 study, percent reductions in fire ant population indices were greater than 80% for all treatments. No significant differences were noted between the pupae and traditional formulations. The prevalence of non-S. *invicta* was greater in the pupae treatments, for the fenoxycarb and pynproxyfen treatments. The sulfluramid corn grit treatment had higher non-S. *invicta* percentages than the pupae, however pretreatment non-target ant counts were unusually high in the grit treatment. Non-S. *invicta* counts were greatest in the fenoxycarb-pupae formulation. Nineteen non-*S. invicta* species were collected, with *Cyphomyrmex rimosus* and *Hypoponera opaciceps* being the most prevalent non-target species trapped.

In 1994, differences in reductions in fire ant populations among the fenoxycarb formulations and the standard hydramethylnon bait (Amdro) were not significant (>70%), but were significantly less in the no-soybean oil hydramethylnon formulation at 4.5 weeks (38% reduction). Averaging over all sample dates, fenoxycarb formulations had greater non-*S. invicta* percentages than the hydramethylnon formulations, however percentages were variable among individual sample dates. Fourteen non-S. *invicta* species were collected, with *Cyphomyrmex rimosus* and *Dorymyrmex flavopectus* being the most prevalent non-*S. invicta* species trapped.

Fire Ant Community ABAITment Program

Douglas B. Petty - County Extension Agent
Kristine G. Klein - Assistant specialist
John L. Turner - County Extension Agent
Arkansas Cooperative Extension Service
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Little Rock, AR 72203

Introduction:

During the summer of 1993, a fire ant abatement program was initiated to reduce the population of red imported fire ants in an urban area by treatment of entire city blocks. **The** program was a cooperative effort involving the City of Texarkana Arkansas and the Miller county Cooperative Extension Service. Due to the positive response from the participants, the program was enlarged and repeated in 1994 and 1995.

Methods:

A survey of local doctors and emergency rooms revealed that the imported fire ant was a public health nuisance to people living in Texarkana. The fire ant abatement program was an attempt to address this problem.
Organization:
Each city block involved selected a coordinator to work directly with the City and the Extension Service in organization of treatments, payments, problem solving and dissemination of information to residents. coordinators also received special training on fire ant control practices. Blocks participating must have at least 80%, but preferably 100% resident participation. Fees of $1.50 per 1,000 square feet, are assessed from each homeowner to cover the cost of insecticides, equipment and labor. If residents were unsure as to lot size, a grid overlaid on city maps was used to determine square footage. Persons wishing to pay for treatment of another's lot, could do so after obtaining written permission. Property eligible for treatment included residential and non-profit organizations such as churches found within neighborhoods.
Treatments:
The initial implementation of the program could not support the cost of labor, therefore employees of the Public Works Department of Texarkana applied the chemical treatments. Cooperative Extension agents provided the technical assistance. The baits were bought in bulk from a local distributor. Treatments began after April 15, with a broadcast treatment of a bait insecticide, Amdro, applied by a Herd spreader mounted on a rented lawn tractor with mowing deck removed. As recommended by the Miller county Extension Service, a broadcast treatment or individual mound treatment

was applied in mid-May. Residents were then given small flags to mark any additional reappearing mounds. City workers used Orthene, a contact insecticide, to treat marked mounds on a three week cycle through the end of August. A follow-up application of a growth-regulator bait, Logic, was broadcast at the end of the treatment period to reduce the possibility of reinfestation.

Results and Discussion:

In 1993, twenty-nine city blocks were enrolled in the program totalling 90 treated acres. The average lot was 16,346 square feet with a cost of $24.52. Payments totalling $5,860 were received. This was sufficient to cover expense of the chemicals, $2,643, with the remaining $3,217 used to purchase the lawn tractor. Treatments consisted of: 1 1/2 lbs/A of Amdro on April 22, 3 Tbsp/mound of Amdro on May 5, 2 tsp/mound of Orthene on May 17, June 1, June 28 and October 4, and 1 1/2 lbs/A of Logic on September 17. Three neighborhoods contained 50′ by 50′ test plots to evaluate the success of the program, Castleridge, Sanderson Lane and East Street (Tables 1,2 and 3). The treated plots showed a 96 to 100% reduction in active fire ant mounds. A survey was mailed in the spring of 1994 to all who participated in 1993. Eighty-four of the 239 surveys mailed were returned. Responses are shown in Table 4. It is interesting to note that even though 6% feel they did not receive their money's worth, 100% were interested in participating in 1994.

In 1994, forty-nine city blocks were enrolled totalling 201 treated acres. Payments received equalled $13,145, with the cost of chemicals totalling $5,382. Treatments consisted of 1 1/2 lbs/A of Amdro in late April, three individual mound treatments of Amdro or Orthene from May through August and a final broadcast application of 1 1/2 lbs/A of Amdro or Logic in September. Individual mound treatment schedules did not follow the three week cycle of the previous year due to other demands on the city workers or weather conditions. In 1993 and 1994, the cost of labor was negligible since the city workers were already paid by the city. The program involved 896 man hours, half of which was provided by Community Service workers.

As of April 1995, enrollment equalled that of the previous year. Profits from the program made it possible to hire a city employee ($6.10/hr) for the summer to make treatment applications and perform other duties relative to maintaining the program. This should provide a level of consistency in the application of the program. City and Community Service workers will continue to provide some of the labor but at a much lower level.

Some residents that have participated since the beginning have expressed reluctance to continue to fund treatment of their lot since they have no or very minimal problems with the fire ant at this time. This problem was overlooked in the beginning, but will be addressed in the future through education of new participants. It is important for the residents to understand that one or two years of fire ant control is not permanent and financial support is necessary to maintain fire ant suppression by either reduced treatment rates on their own property or treatment of buffer zones.

In 1995, a scaled down maintenance program is being considered for those individuals that have been in the regular program in previous years. This would consist of one full rate broadcast bait application and one or two reduced rate bait applications at a lower cost per square foot. No treatment of individual mounds would occur. Depending on the success of the reduced treatments, later maintenance programs might treat only buffer zones or reduce resident treatment even further. Much of the success will depend on the residents expectations on control, some might be willing to tolerate a low number of mounds whereas others may expect no fire ant activity.

Another potential question that will arise as the area of residential treatment enlarges, is the effect untreated commercial areas will have on adjoining abatement neighborhoods. These areas will be a source of continual reinfestation unless some method of treatment is used. Solutions to this problem have yet to be explored.

Table 1. Castleridge Abatement Plots

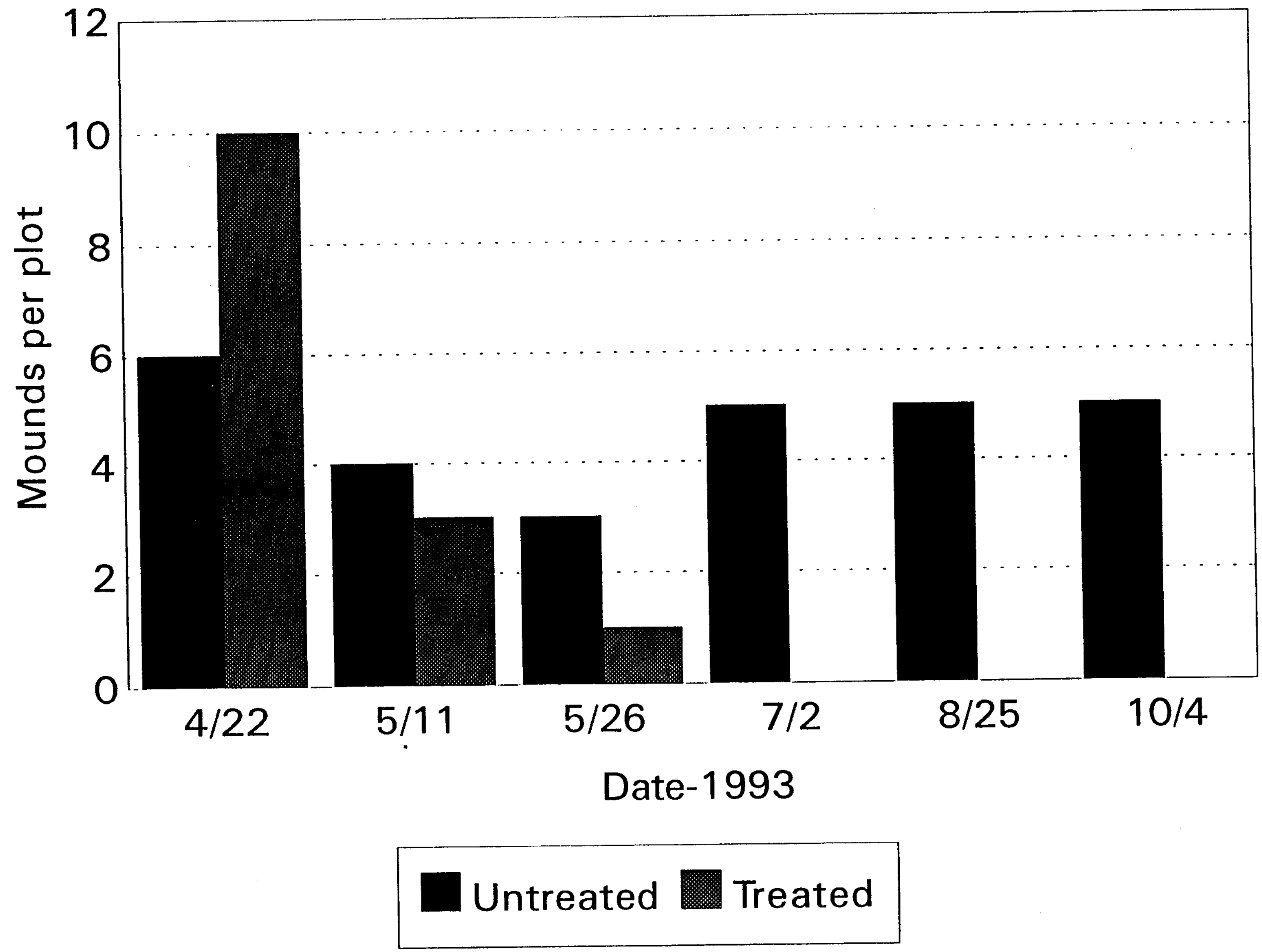


Table 2. Sanderson Lane Abatement Plots

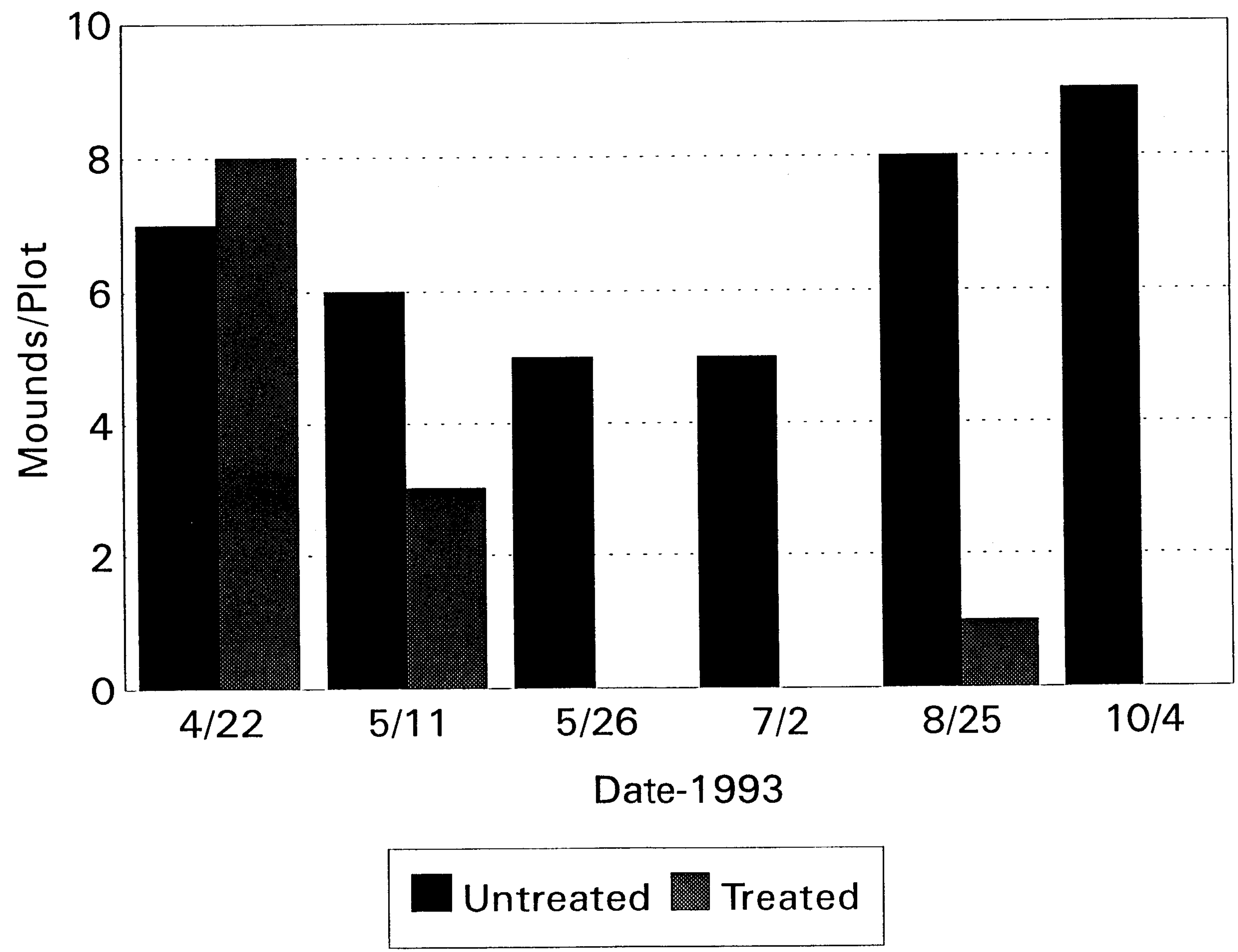
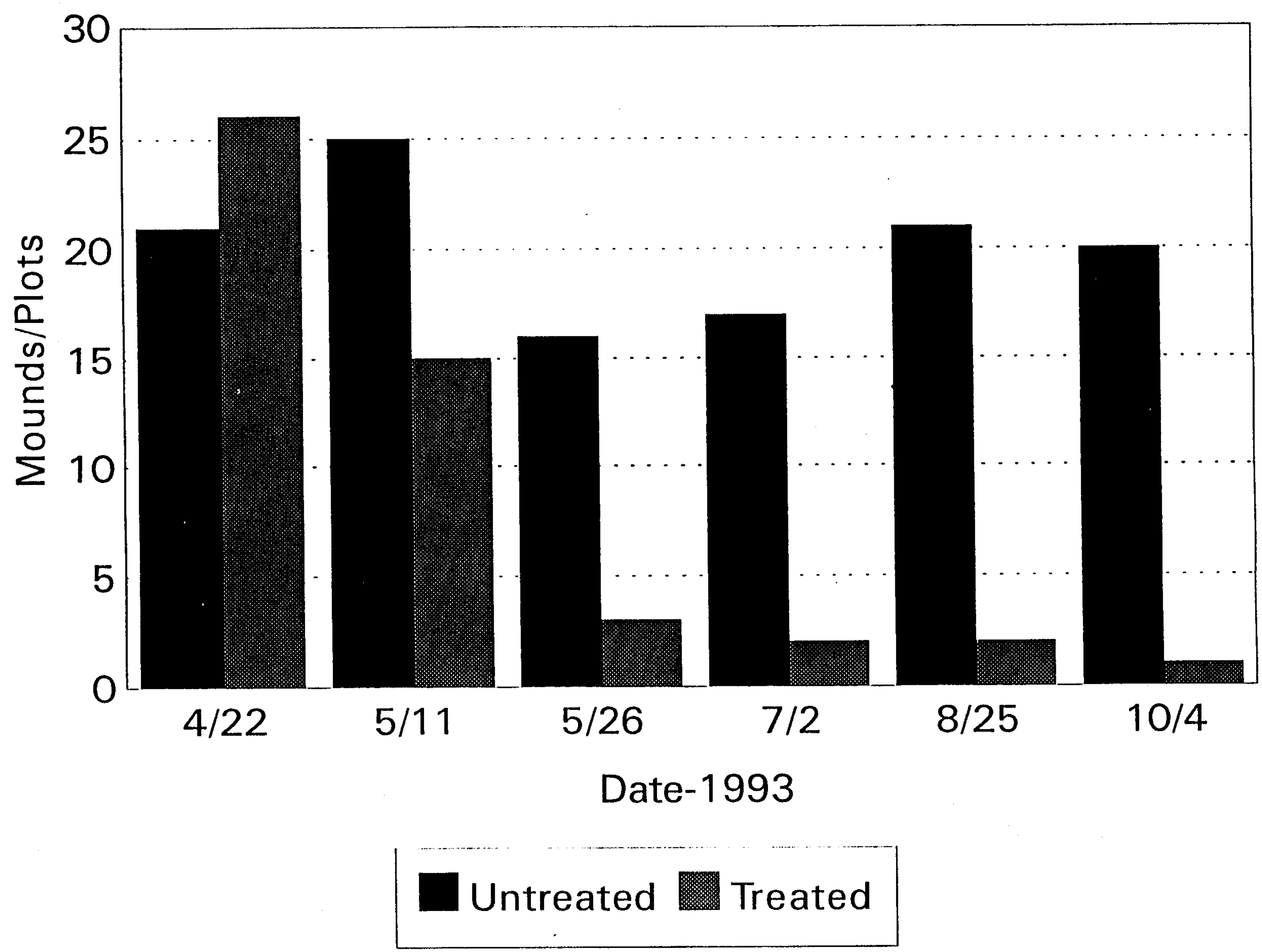


Table 3. East Street Abatement Plots



COOPERATIVE EXTENSION SERVICE
University of Arkansas Division of Agriculture, United States Department of Agriculture, and County Governments Cooperating

Table 4

FIRE ANT ABATEMENT PROGRAM SURVEY

Please do not sign. Circle appropriate answer.

1. How would you rate your fire ant problems in the past?

   mild 4% average 66% severe 30%

2. Which part of your yard has the worst problem with fire ants?

   front yard 40% around house 27% backyard 33%

3. Is anyone in your household allergic to fire ant stings?

   yes 26% no 32% not sure 42%

4. Have fire ants ever caused any electrical problems around your house?

   yes 4% no 96%

5. Do fire ants bother your pets?

   yes 14% no 40% no pets 36%

6. How well did the Fire Ant Abatement Program control your fire ants last year?

   poor 1% fair 13% well 48% excellent 38%

7. Do you feel you received your money's worth from last year's program?

   yes 94% no 6%

8. Would you be interested in participating again this year?

   yes 100% no 0%

9. Were you notified of treatment dates?

   always 37% most times 35% sometimes 24% never 4%

10. How many members are in your household? 232 Total

11. Any comments of last year's program and suggestions for improvements for this year.

Please return to:

Miller County Extension Service 400 Laurel, Suite 319 Texarkana, AR 75502-5289

Development of Pheromone Enhanced Baits and Other Technology Transfer Activities

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PHEROMONE ENHANCED BAITS. Work is continuing on the enhancement of fire ant baits with attractant pheromones through a CRADA with American Cyanamid. We have already demonstrated that fire ants discover pheromone enhanced baits quicker and that they discover more of the bait particles. Besides single mound treatments we have also demonstrated the effectiveness of the pheromone formulation in large scale broadcast treatments. A formulation with 1/3rd less active ingredient gives results equivalent to standard AMDRO. A consequence of all of the above is that there will be less active ingredient for non-target ants to find. Thus, there should be fewer effects on non-target ants. The spinoff from this consequence is that more non-target ants will be available to predate on newly mated fire ant queens. We predict that fire ant reinfestation rates will be slower in areas treated with pheromone enhanced baits then in areas where standard bait was used. We currently have large field tests underway to test this prediction. Other independent tests are being conducted this year to determine the broad applicability of the technology (Vander Meer, et al. Patent Pending).

REPELLENTS. True repellents are compounds that do not require contact by the responding organism, but instead act through space. Many repellents with a variety of structural moieties, e.g. alcohols, carboxylic acids, alkynes, alkenes and esters were discovered using a Y-tube olfactometer (Vander Meer, et al. Patent Pending). All of these compounds are volatile and require controlled release technology. We have a Cooperative Research and Development Agreement (CRADA) with Hercon Environmental, Inc. to utilize their polymer laminate controlled release technology to increase repellent longevity. This technology transfer has been very successful and we now have bioactive formulations that have an active life of up to a year and a half. The amount of repellent / laminate required for excluding fire ants from specific volumes are currently being tested.

DIATOMACEOUS EARTH / PYRETHRINS. We have another CRADA with Organic Plus, Inc. Albuquerque, New Mexico. Diatomaceous earth (DE) is an excellent carrier for insecticides. Organic Plus, Inc. produces an organic insecticide formulation that consists of natural pyrethrins and piperonyl butoxide absorbed into DE. This formulation prevents fire ant colonies from migrating into pots containing soil treated with the pyrethrin/DE formulation. Concentrations of 100ppm were 100% effective at keeping fire ants out of soil after over a year. This formulation may find a useful niche in quarantine activities. Additional work is continuing with Organic Plus, Inc. and will be reported at the next Fire Ant Conference.

Literature Cited

Vander Meer, R.K., Banks, W.A., and Lofgren, C.S., Patent Application Pending, Serial No. 071925685 - A repellent for ants.

Vander Meer, R.K., Seawright, J., and Brocious, S. Patent Application Pending, Serial No. 08/231,214 - Pheromone enhancement of ant baits.

EVALUATION OF TRUE STOP™ FIRE ANT INSECTICIDE EFFICACY
ON RED IMPORTETD FIRE ANT (Solenopsis invicta Buren) CONTROL

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Introduction

Formulations of rotenone are available for fire ant control. In most of them, either a relatively high amount of active ingredient(s) (5-10%) of both the cube and the resins is used, or presented as in association with other active ingredients as binary or ternary products. In most liquid formulations, the rotenone is carried in a synthetic petroleum solvent. True Stop™ presents a unique instance where 0.62% rotenone is stabilized in a refined dairy "manure slurry". It is approved by EPA as Fire Ant Insecticide (EPA# 066070-1 and EPA Est.# 66070-TX-001) with no restriction when used according to label instructions. Several field and laboratory studies have been conducted to evaluate True Stop™ efficacy for fire ant control. Results of some of them are presented.

I. LABORATORY STUDY

LD_{50} determination using the Filter Paper Method

Materials and Methods

Ant colony was reared in 5-gallon bucket to served as test subjects. Doses were chosen to simulate field rate and comprised of: 0.11, 0.21, 0.32, and 0.42 ml a.i./10 ml of water and represented (0.25, 0.50, 0.75 and 1 label rate respectively). Water was used as treatment for natural control mortality. Whatman 9.0 cm filter papers were placed in petri dish. Talk powder was used on the rims of the petri dishes to prevent the ants from escaping. The filter paper was then saturated with 1.5 ml solution of each rate. An average of approximately 63 ants were used per dish. Each dose treatment was replicated 4 times. Reading was made 10mn later. Mortality was assessed by recording complete motionless or when ants were showing moribund sign (sluggish and loss of locomotion control). Mortality data were corrected for control mortality using Abbott's (1925) formula. Analysis was performed using Polo at $g < 0.5$.

Results and Discussion

Results are shown on Tables 1 & 2. The Response/Subject ratio (R/S) indicated that at the lowest exposition dose, True Stop™ R/S ratio was not considerably more efficient than water alone (0.09 vs. 0.06 respectively). However, a R/S of 50 was almost reached at 3/4 (0.32ml a.i. /10ml) of the commercial dose (R/S = 0.49). The present label rate showed a R/S of 0.69 (0.42ml a.i./10ml) (Table 1).

TABLE 1. Evaluation of RIFA mortality at different doses of TRUE STOP™ Fire Ant Insecticide using the Filter Paper Method. 1995.

Doses (ml a.i.-10 ml)	Subjects	LD50 Responses	LD50 Expected	R/S Ratio
0.11	276	25	29.50	0.09
0.21	343	117	105.28	0.34
0.32	292	142	153.93	0.49
0.42	**199**	**138**	**134.16**	**0.69**
Natural	157	9	7.95	0.06

The calculated LD_{10}, LD_{50} and LD_{95} were 0.13, 0.32, and 0.98 respectively; a field rate of 47.3, 107.4 and 329.3 ml/gal. (Table 2).

TABLE 2. Effective toxicity of TRUE STOP™ Fire Ant Insecticide on RIFA using the Filter Paper Method to test different lethal dose settings; $g < 0.5$. 1995.

Lethal Doses	Upper	Lower	Calculated	Equivalent Field Dose
LD_{10}	0.193	0.032	0.133	50.34 ml/gal.
LD_{50}	**0.462**	**0.238**	**0.319[a]**	**121.12 ml/gal.**
LD_{95}	7.486	0.595	0.979	370.55 ml/gal.
Subjects[b]	1267 (1110; 157)			
Slope ±SEM	3.38±0.31			
X^2	5.09			
df	2			
g value[c]	0.394			

[a]0.42 A.I. currently used (160ml/gal).
[b]Treated: 1110; untreated: 157.
[c]Finney 1972.

Comparing the calculated field rate that gave 50% mortality (121.12ml a.i./gal), with the label rate (160 ml/gal.), it is therefore possible to have a considerable 24.3% reduction of the amount of active ingredient in the commercial product without hindering efficacy. However, the natural properties of rotenone (easily degraded by ambient factors) and the absence of any synthetic synergists in the formulation dictated this more conservative approach. The low amount of rotenone could also contribute to the reduction of the incidence of exposure to non-target orgamisms.

II. FIELD STUDIES

1- Texas A&M Research and Extension Center, Stephenville, TX. North Central Texas, 1994 and 1995.

Objective: Screening test to gain some knowledge of the products potential on fire ants.

Materials and Methods

Technical information on products used are presented on Table 3.

TABLE 3. Technical information on TRUE STOP™ and two other botanical insecticides tested for RIFA control. TAES. Stephenville, TX. 1994 and 1995[a].

Insecticides	Amount A.I. (%)	Inert Ing.	Dilution Rate	Company
True Stop™	Rotenone: 0.62	99.38	24:1 (160 ml/gal)	Sphere Corp.
Green Light™ Plus Organo Spray	Rotenone: 3.30 Pyrethrins: 0.80	95.9	189:1 (20 ml/gal)	Green Light
High Yield™	Rotenone: 2.25	97.75	None (dust)	V.P.G. Inc.
Untreated Check	-	-	-	-

[a]Source: Cocke et al. 1994 and 1995 (Unpublished).

True Stop™ Fire Ant Insecticide (0.62% a.i. total rotenone) Sphere Corp.Gerogetown TX was compared to two other botanical insecticides Green Light™ Plus Organo Spray -GLPOS- (3.3% total rotenone and 0.80% pyrethrins) Green Light, San Antonio TX, and High Yield™ Rotenone dust (2.25% total rotenone) Voluntary Purchasing Group, Bonham TX for RIFA control.

A completely randomized design was used. Each treatment was comprised of 56, 60, 56, and 33 mounds in 1994 and 33 mounds per treatment in 1995 (True Stop™, GLPOS, High Yield™ and control, respectively). Dilution rate for each was as indicated on Table 3. Approximately 360-480 ml of solution was used as drench. High Yield™ dust was used at a rate of 1-2 teaspoons per mound top. Treatments were evaluated at DAT = 14 in 1994 and DAT = 180 in 1995 for mound activity using a 0-5 rating scale where: 0=No activity or soil mixing; 1=Slight activity with little or no soil mixing; 2=Some activity with some soil mixing; 3=Moderate activity with slightly half mound mixed; 4=Very active with more than half of the mound mixed; and 5=Completely active. In 1995, the scale rating range was 1-4. Results were analyzed by ANOVA and means separated in 1994 by S-N-K and by Fisher lsd in 1995 both at 0.05 .

Results and Discussion

Mound activity was significantly reduced by either True Stop™ or GLPOS drenches. Results indicated no significant difference between the two drench formulations, but a significant effect was observed when compared with untreated mounds or High Yield™ treatments (p=0.05) in both years.

True Stop™ was as effective as GLPOS in controlling RIFA. However, since the two tests did not include independent and component combination treatments of True Stop™ and GLPOS, no inferences were made by the authors about the independent and/or interaction effects of the components.

TABLE 4. Comparison of TRUE STOP™ Fire Ant Insecticide efficacy with two botanical insecticides for RIFA control at D.A.T. = 14 (1994) and D.A.T. = 180 (1995). Texas Agricultural Extension Service Stephenville, TX

	Mound Activity (Rating = 0-5)[b]		Nb. of Mounds	
Treatments	1994	1995	1994	1995
Untreated Check	4.32a[c]	4.18a	33	33
High Yield™	2.38b	3.88a	56	33
True Stop™	0.68c	1.58b	56	33
Green Light™ Plus Organo Spray	0.09c	1.78b	60	33

[a]Source: Cocke et al. 1994 and 1995 (Unpublished)
[b]Rating: 0=Not active or soil mixing 1=Slight with little or no; 2=Some with some mixing; 3=Moderate with slightly half mixing; 4=Very with >1/2 mixing; 5=Very active
[c]Means followed by the same letter(s) are not significantly different. S-N-K at p=0.05

The authors mentioned that the lack of block design did not allow to evaluate satellite mound activity within the treatment area. A larger scale study of True Stop efficacy on fire ant control is being conducted in the 24 counties of the Noth Central Texas to validate the preliminary findings.

2- Austin State Hospital Fire Ant Control Campaign. 1995

Fire ant activity is an important topic in spring and summer times in the premises of the 119-acre Austin State School. Several outdoors activities are either terminated or restricted in the rare non-infested areas in the facilities. Control methods were limited to frequent spot application of diazinon granular formulation or orthene dust. Due to the possible drift of the orthene, the exposure of the granular diazinon to mental patients, alternative control options were sought (Williamson, pers. comm).

Sphere Corporation volunteered to treated the infested area. A total of 228 mounds were flagged and mapped to account for relocation or new occupation after treatment. The product was mixed at the label rate in two 32 gallon plastic trash cans and drenched in the mound at a rate of 0.50-1gal. of mixture per mound.

Control was evaluated after mound excavation at DAT=60. Mound was considered dead when no activity was noticed after 5-10 seconds of disturbance, followed by the absence of brood after excavation. A randomly selected number of 55 mounds were excavated. Results are presented in Table 5.

TABLE 5. True Stop™ control on fire ant. Austin State Hospital. Excavation. DAT = 60. 1995.

	Nb. of mounds/Control	
Total mound checked	w/ brood	w/o brood
55	3	52
% control		94.6

3- Foust Ranch. Comparison Study. Georgetown, TX.

Introduction

Pasture lands are often sites of RIFA colonization for several reasons. They are usually open and frequently disturbed lands and good foraging habitat suitable for new colony settlement. The RIFA colonization of these areas presents a problem to the cattle and other animal dwellers. Ranchers are usually reluctant to use traditional pesticides either baits or dust due to the potential of endangering their animals. Even though bait application is suggested in large scale infestation followed by individual treatment (drench, etc..), the period of time required to have a good control is usually long. Individual mound treatment in polygynous infested area could be very labor intensive but present a shorter period before control is obtained.

Ranchers are also concerned with the long residual effect of the synthetic pesticides as well as the botanical formulations with petroleum distillate solvents. The introduction of True Stop™ Fire Ant Insecticide has gained rapid adoption due to its sole property as a botanical insecticide stabilized in organic liquid medium, the low amount of rotenone content, its biodegradability and the rich nutrient content of the organic solvent. Its No-restriction label in pasture is also an advantage.

This study was conducted to evaluate True Stop™ efficacy with two botanical insecticides and Orhtene. It was also intended to duplicate the Stephenville screening test (Cocke, unpublished 1994).

Materials and Methods

Field study was conducted in 2.5 acres of the Foust Ranch, 10 mi West of Georgetown TX on I-29 to evaluate True Stop™ (0.21% rotenone + 0.42% resin) efficacy on fire ant control, compared with Green Light™ Plus Organo Spray (1.1% rotenone + 2.2% resins + 0.8% pyrethrins), High Yield™ Rotenone Insecticide (dust) (0.75% rotenone + 1.5% resins). Orthene Fire Ant Killer (75% acephate) was used as non botanical insecticide for control.

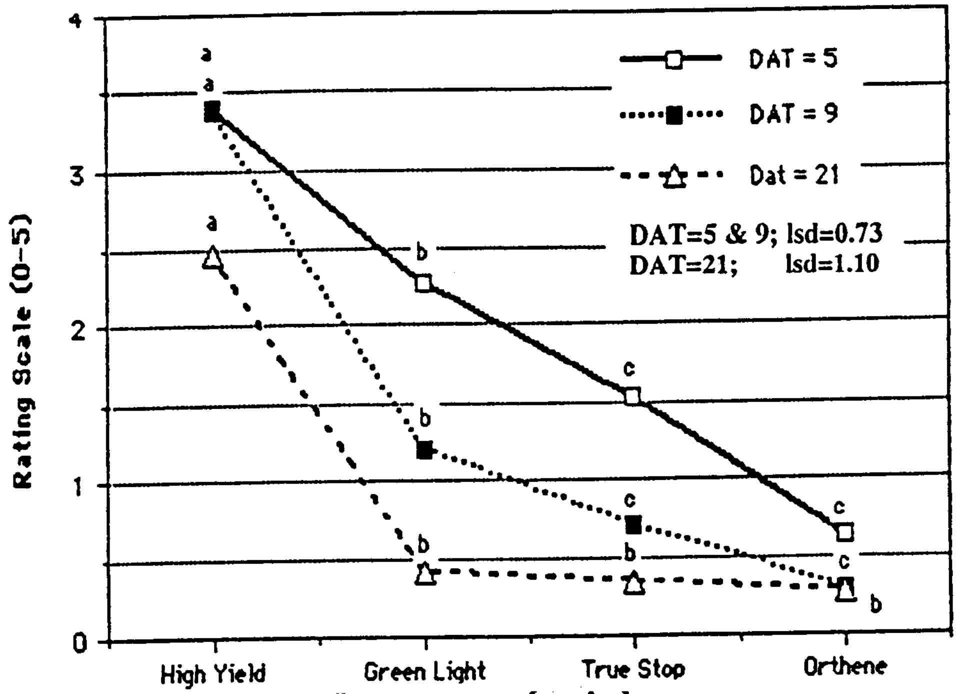
A Randomized Block Design was utilized with 4 treatments (True Stop™, Green Light™ Plus Organo Spray (GLPOS), High Yield™ and Orthene™ as control), 4 replications (blocks) per treatment and 10 active mounds (with brood) per treatment to give a total of 160 mounds. Treatments were randomly assigned to the mounds and flagged. Each mound was mapped and recorded in the monitoring form to account for post treatment satellite formation at a 3-5 ft radius from the mound. Monitoring activities were performed at DAT = 5, 9, and excavation at DAT = 21. Activity was assessed by disturbance and rating in a scale of 0-5. Control was evaluated after excavation of 15 mounds per treatment and rated according to activity and absence/presence of brood. Rating was: 0=None; 1=Very little; 2=Little; 3=Moderate; 4=High; 5=Very high. Data were analyzed by ANOVA and means separated by Fisher Protected LSD at $p < 0.05$ (Statistica, 1994).

Results and Discussion

Results are summarized in Fig.1. and Table 6.

Mound activity at DAT=5 showed a significant effect on all treatments imposed. Activity were recorded in decreasing order as follow: High Yield™(3.40) > Green Light™(2.28) > True Stop™(1.53) > Orhtene™(0.63). At DAT=9, the same trend was observed. While significant increased of activity was found in High Yield treated mounds compared to the rest, True Stop and Orthene performed equally well. There was still a slight favorable trend of less activity on Orthene™ treatments. At the final reading period and excavation at DAT=21, High Yield were the sole treatment presenting a significantly higher mound activity (2.47). The other three treatments were significantly identical in efficacy in controlling RIFA.
The study supported the findings of Cocke et al. (1994) in comparing True Stop with Green Light. It also shows that True Stop™ could be a competitive alternative to Orthene. It also shows that Orthene has a relatively more rapid knock down effect, compared to the slow acting effect of True Stop.

FIGURE 1. Mean Activity Comparison of TRUE STOP™ Fire Ant Insecticide efficacy with two botanical insecticides and Orthene (Control) for RIFA control at different number of Days After Treatment (DAT). Foust Ranch, Georgetown TX. 1995.



Effect of insecticide applications on RIFA activity and control. Foust Ranch. Gerogetown, TX. 1995. *Means on same line and with same letter are not significantly different. F.Lsd 0.73 and 1.10; p<0.05*

Table 6. Comparison of Means difference among treatments. TRUE STOP™ Fire Ant Insecticide efficacy with two botanical insecticides and Orthene (Control) for RIFA control at different number of Days After Treatment (DAT). Foust Ranch, Georgetown TX. 1995.

	DAT		
Comparisons	5	9	21
True Stop Vs. High Yield	1.88*[a]	2.68*	2.13*
True Stop Vs. Green Light	0.75*	1.28*	0.07
True Stop Vs. Orthene	0.9*	0.43	0.07
LSD	0.73	0.73	1.10

[a]Mean comparison with * indicates significant difference at LSD = 0.73 and 1.10 for DAT=5 and 9, DAT=21, respectively. Fisher LSD at 0.05.

The later could be a favorable factor at keeping the mound in place while still dying. Satellite formations or hot spots were observed in treatments in some instance but they were not viable in any of the treatments at the time of excavationexcept on High Yield™ treatment. This could explain the poor control observed in such treated mounds.

Observed mortality when based on visual observation will tend to show more dead ant piles on mounds treated with True Stop™. This occurrence, even though already documented in ants and social insect behavior is considerably remarkable after True Stop™ application. We suspect a relatively high content of fatty acids and/or other biochemical compounds in the mixture; some have been reported to trigger workers to carry outside the nest dead, dying ants or even live ants covered with a finite amount of these compounds(Hölldobler and Wilson 1990). If this hypothesis is tested and accepted, it could explain the True Stop™ necrophoresis enhancement. Studies are under way.

In summary, True Stop™ can be considered as a good alternative for RIFA control as part of an IPM program. In general, the limitation of the drench application method is the intensive labor requirement when dealing with large area. The improvement of application technique using high volume mixing, pressurized tank and motorized unit could shift the recommended application program. Liquid botanical insecticides for fire ant control are usually carried in a petroleum distillate solvent. This is a deterrent to most organic gardeners or environmentalists. True Stop™ formulation is novel in using an organic solvent to stabilize and enhance the rotenone potency (Faye, unpublished). In addition, a significant reduction of activity after exacavation, considerableant mortality without significant relocation and a considerable "graveyard formation" of workers, brood and queens on mound top and side constitute a reassuring proof of mound control.

Acknowledgments

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References Cited

Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. J.E.E. 18:265-67.
Cocke, J. M. Morris, S. Fuchs, and L. Butts. 1994 and 1995. Effects of True Stop™ Fire Ant Insecticide on Red Imported Fire Ant Mounds in North Central Texas. (unpublished).
Finney, D.J. 1972. Probit Analysis. p. 79.
Hölldobler, B. and E.O. Wilson. 1990. The Ants. The Belknap Press of the Harvard University Press. Cambridge, Massachussets. 732 pp.
LeOra Software. Polo.PC. Copyright 1987.
StatSoft. 1994. STATISTICA™ for the Macintosh. Vol. 1-3. 2325 E. 13th. St. Tulsa OK. 74104.

A LAWN CARE OPERATOR'S APPROACH TO NEIGHBORHOOD FIRE ANT CONTROL

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At the 1994 Annual Imported Fire Ant Conference we reported on an area wide treatment program in Arkansas, utilizing aerial application of bait. For small and medium sized towns this is a very effective way to control IFA on a large scale. Larger towns and cities are not adapted to aerial applications due to the inability to fly at acceptable altitudes because of FAA regulations, obstructions and density of non-labeled sites. Our objective was to evaluate the feasibility of an area wide broadcast bait treatment program in a large metropolitan area.

A neighborhood approach was determined to be manageable, and a cooperative effort was soon born between Cyanamid, TAES, and TrueGreen ChemLawn. The support of TAES was essential in providing credibility to our efforts as a supporter of broadcast bait applications. TrueGreen ChemLawn is a well respected national lawn care operation that utilizes broadcast bait applications for control of IFA.

The ElDorado community in McKinney, TX was chosen as the site for the pilot program due to the presence of a significant IFA problem, the manageable lot sizes (5,000 sq ft), and the financial ability (middle to middle upper class) to purchase an IFA treatment program. A 200 home section was targeted for the program although the neighborhood consisted of over 700 homes. Initially, a neighborhood meeting was to be the means to introduce the program, however, ElDorado did not have routine homeowner meetings. Direct mail was chosen as the source of introducing the program. An introductory letter, Amdro fact sheet, and sign-up card were sent to the homeowners. The letter described the program and indicated that two broadcast applications (spring and fall) and a mid-summer spot treatment would provide season long control. The more homeowners that signed up the more effective the control. The cost for the year long program was a nominal $15.

After receiving sign-up cards, homes that did not respond were personally visited to interest them in the program. A total of 80 homes signed up for the program. Many homeowners (approximately 50%) were not at home during the follow-up or this number could have potentially been much greater. Homeowners that were not interested in the program cited lack of an IFA problem, do-it-yourself, or have a current service as reasons for not signing up.

The initial broadcast application was made in mid May to the lawns at a rate of 1.5 lbs of Amdro per Acre using chest mounted spinner spreaders. Prior to the application date, homeowners were asked to unlock fences, turn off irrigation, and place aggressive pets inside. In addition to the 80 home lawns being treated, the grounds surrounding the elementary school which was located in the neighborhood, was also treated. Many of the parents and children walk through the turf and use the playing fields on a daily basis.

The mid-summer spot treatment was performed in June following a mailing to homeowners which included the treatment date and flags to identify any active mounds in the lawn. Flagging mounds made the summer application proceed very efficiently and allowed us to determine the number of fire ant free lawns. Only 10 of the 80 lawns contained any active mounds, resulting in 88% fire ant free lawns. Most of the flagged properties had one or two active mounds. These mounds were spot treated with Amdro at 5 tablespoons per mound.

The fall application was made in October utilizing similar methods used for the spring application. Homeowners were solicited at that time to obtain their comments on the effectiveness of the program. All homeowners that we talked with were very pleased with the outcome and were willing to be involved again in 1995.

Throughout the program, messages were broadcast on the local cable television public access channel to communicate the project with people in the area and update them as necessary. Over 30 calls were fielded by the local extension office resulting from the cable messages. In most cases calls were to inquire about the specifics of the program and if they could become involved.

Overall, the program was viewed as a very successful way to control IFA season long in a neighborhood setting. TrueGreen ChemLawn in 1995 is evaluating a similar type approach in other parts of Texas.

EFFECTS OF LOGIC® AND AMDRO® BAITS ON NONTARGET ANTS

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Summary

Twelve sites receiving repeated broadcast applications of Logic® and Amdro® baits for red imported fire ant control *(Solenopsis invicta* Buren) were examined for their effects on ant diversity in southeastern Arkansas. Our sugar-bait sampling methods assessed the native ants that normally interact with fire ants within their common territories. Absence of insecticides at the check plots allowed comparative estimates of bait effects on species composition. Ants collected from baits belonged to **3** subfamilies and *25* species. As compared with checks, ant species increased dramatically on Logic plots, while they decreased on Amdro plots. Ants within the subfamily Myrmicinae practically disappeared from Arndro plots. However, these ants remained on Logic plots, and their relative densities increased. Sensitivity of ants in the subfamilies Formicinae and Dolichoderinae to Amdro and Logic was comparatively low. As a consequence, Logic may be a desirable insecticide for the integrated management of imported fire ants.

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PRE-ADULT LEARNING IN THE RED IMPORTED FIRE ANT

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ABSTRACT

We placed 14 paired replicates of five polygyne queens each into nest fragments containing pupae from either monogyne or polygyne colonies. Callows emerging from monogyne pupae quickly assassinated queens, in most cases leaving only one alive. On the other hand, callows from polygyne pupae usually kept most of their test queens alive. In a second cross-fostering experiment, monogyne brood were reared by polygne ants, and polygyne brood by monogyne ants. When these cross-fostered brood became pupae, each group of pupae was put into a separate test chamber with 3 polygyne queens. This procedure was replicated 10 times. As the pupae became callows, we recorded queen mortality for 2 months. Although the workers emerging from monogyne pupae still killed more queens than those emerging from polygyne pupae, the outcome was much less pronounced than in the first experiment. We conclude that at least part of the queen-killing behavior is due to pre-adult learning involving recognition of either nestmates or queens.

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ALPHABETIZED LIST OF SENIOR AUTHORS
OF
IMPORTED FIRE ANT CONFERENCE PROCEEDINGS
AND
5TH INTERNATIONAL PEST ANT SYMPOSIA

1. ALI, D., T. E. REAGAN and J. L. FLYNN. 1984. Influence of Selected Weedy and Weed-Free Sugarcane Habitats on Diet Composition and Foraging Activity of the Imported Fire Ant. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL.(Abstract only) p. 7.

2. ALLEN, C., S. DEMARAIS and R. S. LUIZ. 1993. The Response of Nongame Wildlife to Red Imported Fire Ant Reductions. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. p. 117.

3. ALVAREZ, F., R. K. VANDER MEER and C. S. LOFGREN. 1984. Isolation of the Phermones of *Solenopsis invicta* and *S. richteri*. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 162-178.

4. AMADOW, B. S., and S. A. PHILLIPS, JR. 1994. Yeast Flora of the Red Imported Fire Ant. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 53-54.

5. BALL, D. 1984. Effect of Pro-Drone on the Fire Ant, *Solenopsis invicta* Buren. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. (Abstract only) p. 26.

6. BANKS, W. A. 1986. Control of Imported Fire Ants with New IGR and Fluorocarbon Baits. Proc. of the 1986 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Texas Dept. of Agriculture, Austin, Texas. pp. 76-82.

7. BANKS, W. A. 1987. Studies with Baits for Control of Multiple Queen Populations of Red Imported Fire Ants. Proc. of the 1987 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Louisiana State University, Baton Rouge, Louisiana. pp. 39-48.

8. BANKS, W. A. 1988. Nuptial Flight Studies of Monogynous and Polygynous Colonies of Red Imported Fire Ants. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 37-43.

9. BANKS, W. A. 1989. Effectiveness of the Sumitomo IGR S-31183 Against the Red Imported Fire Ant. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 132-141.

10. BANKS, W. A. 1989. A Tribute to Dr. Clifford S. Lofgren: Mr. Fire Ant. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 2-7.

11. BANKS, W. A. 1990. Effects of Teflubenzuron on Laboratory Colonies of the Imported Fire Ant. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. pp. 55-61.

12. BANOV, C. 1993. IFA Allergy: Diagnosis and Management. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. p. 98.

13. BARR, C. L. and B. M. DREES. 1994. Texas Veterinary Survey: Impact of Red Imported Fire Ants on Texas Animal Health. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 35-44.

14. BARR, C. L. and B. M. DREES. 1995. Texas cattle producer's survey: Impact of red imported fire ants on the Texas cattle industry. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 138-145.

15. BENSON, L. 1984. An Update on RO-13-5223 (Logic Fire Ant Insecticide). Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 197-204.

16. BHATKAR, A. P. 1986. Movement of Marked Workers Between the Fire Ant Mounds in a Texas Pasture Habitat. Proc. of the 1986 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Texas Dept. of Agriculture, Austin, Texas. p. 16.

17. BHATKAR, A. P. 1990. The Imported Fire Ant in Urban Environments. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. pp. 19-21.

18. BHATKAR, A. P. and R. E. GOLD. 1991. Red Imported Fire Ant in Urban Environments: Current Research Status. Proc. of the 1991 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., The University of Georgia, Athens, Georgia. pp. 112-113.

19. BHATKAR, A. P., R. R. DUNTON and S. B. VINSON. 1987. Sex Ratios in Mono- and Polydomous *Solenopsis invicta* Populations. Proc. of the 1987 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Louisiana State University, Baton Rouge, Louisiana. p. 25.

20. BOSWORTH, J. and R. K. VANDER MEER. 1984. Colony Founding Minums: A New *Solenopsis invicta* caste. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 92-105.

21. CALLCOTT, A-M. 1989. Influence of Soil Type and Other Environmental Factors on Toxicity of Chlorpyrifos to Imported Fire Ants. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 143-160.

22. CALLCOTT, A-M. 1990. Effects of MOBAY NTN33893 on Imported Fire Ants. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. pp. 99-108.

23. CALLCOTT, A-M. 1992. Factors Influencing Residual Activity of Chlorpyrifos in Nursery Potting Media. Proc. of the 1992 Imported Fire Ant Conference (C. S. Lofgren, ed.). Dept. of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico. pp. 59-76.

24. CALLCOTT, A-M. 1993. Tefluthrin: A Promising New Imported Fire Ant Quarantine Insecticide. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 47-57.

25. CALLCOTT, A-M. 1994. 1993 Field Trials. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 99-108.

26. CALLCOTT, A-M. and H. COLLINS. 1995. IFA electronic bulletin board system: Should we or shouldn't we? Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 107-109.

27. CALLCOTT, A-M. and H. COLLINS. 1995. Invasion and range expansion of imported fire ants in North America from 1918-1993. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 50-61.

28. CAMILO, G. R. and S. A. PHILLIPS, JR. 1988. Disturbance Effect of the Red Imported Fire Ant on Ant Community Structure in Central Texas. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp.155-164.

29. CASTRO, S. 1992. Estudios Preliminars de *Solenopsis invicta* en Siembras de Cana en Puerto Rico. Proc. of the 1992 Imported Fire Ant Conference (C. S. Lofgren, ed.). Dept. of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico. pp. 83-119.

30. CHEN, Y-P. and S. B. VINSON. 1995. Queen dominance in the polygynous ant, *Solenopsis invicta* Buren: (2) The distribution, attractiveness, trophallaxis, and fecundity of queens in laboratory colonies. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 88-89.

31. CHEN, Y-P. and S. B. VINSON. 1995. Queen dominance in the polygynous ant, *Solenopsis invicta* Buren: (1) Queen attractiveness to workers as a mechanism of dominance. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 85-87.

32. COBB, P., W. H. COBB and D. BRADFORD. 1994. An Imported Fire Ant Control Program for Reduction of Labor Costs in a Commercial Landscape: A Preliminary Report. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. p. 137.

33 H. L. T. 1984. Field Trials with Bait Toxicants. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 40-51.

34. COLLINS, H. L. T. 1986. Development of IFA Quarantine Treatments for Nursery Stock. Proc. of the 1986 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Texas Dept. of Agriculture, Austin, Texas. pp. 57-69.

35. COLLINS, H. L. T. 1990. Overview of Current USDA APHIS Research and Development of Quarantine Treatments. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. pp. 80-98.

36. COLLINS, H. L. T. 1992. Management of Imported Fire Ant Populations in Commercial Grass Sod. Proc. of the 1992 Imported Fire Ant Conference (C. S. Lofgren, ed.). Dept. of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico. pp. 50-58.

37. COLLINS, H. L. T. 1993. 1992 Bait Trials. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 73-81.

38. COLLINS, H. L. T., A-M. CALLCOTT and A. LADNER. 1995. Subsurface injection of soil insecticides for control of IFA: Emerging technology or merely a flash in the pan. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 165-169.

39. COLLINS, H., D. F. WILLIAMS and D. HAILE. 1994. Fire Ant Mission to the Amazon: USDA's Humanitarian Assistance to Envira, Brazil. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 3-8.

40. COLLINS, H. L., A. LADNER, A-M. CALLCOTT, and S. TROSTLE. 1988. New

Developments in IFA Quarantine Treatments. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 111-128.

41. COLLINS, H. L., A. LADNER, A-M. CALLCOTT, T. LOCKLEY, and L. McANALLY. 1991. Seasonal Effectiveness of Amdro and Logic for RIFA Control. Proc. of the 1991 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., The University of Georgia, Athens, Georgia. pp. 35-50.

42. COLLINS, H. L., T. LOCKLEY, A-M. CALLCOTT and L. McANALLY. 1991. Bifenthrin: A Promising New Imported Fire Ant Quarantine Treatment for Containerized Nursery Plants. Proc. of the 1991 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., The University of Georgia, Athens, Georgia. pp. 17-34.

43. COOK, J. L., R. E. GOLD and S. B. VINSON. 1995. Prevalence of the strepsipteran, *Caenocholax fenyesi* stylopizing *Solenopsis invicta* colonies in Brazos County, Texas. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 96-101.

44. COPLIN, N. 1989. Control of Imported Fire Ants in Electrical Applications using Stutton Corporation's JS-685. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. p. 142.

45. COTTE, O., J. REYES, and A. L. DAVILA. 1988. Observations on the Fire Ant on Some Crops of Puerto Rico Agriculture. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 95-98.

46. COULTER, D. B. and W. A. CROWELL. 1984. Chronic Toxicity of a Fire Ant Insecticide in Dogs. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. (Abstract only) pp.52-53

47. CRUZ, C. and S. CASTRO. 1984. The Imported Fire Ant in Sugarcane Fields in Puerto Rico. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 8-9.

48. CRUZ, C. and S. CASTRO. 1992. The Imported Fire Ant in Sugarcane Fields in Puerto Rico. Proc. of the 1992 Imported Fire Ant Conference (C. S. Lofgren, ed.). Dept. of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico. pp. 81-82.

49. DEMARAIS, S., C. ALLEN and R. S. LUIZ. 1993. The Response of White-tailed Deer to Red Imported Fire Ant Reductions. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. p. 117.

50. DeSHAZO, M. D. and D. RICHARD. 1994. Medical Consequences of Multiple Fire Ant Stings Occurring Indoors. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 45-46.

51. DIFFIE, S. 1990. Survey of the Economic and Aesthetic Impact of Red Imported Fire Ants on Home Owners in Georgia. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. pp. 22-29.

52. DIFFIE, S. and M. BASS. 1993. The Imported Fire Ant Hybrid in Georgia: Its Survivability, Range Expansion, and Control. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 35-46.

53. DIFFIE. S. and D. C. SHEPPARD. 1988. Supercooling Studies and Winter Mortality Studies Involving *Solenopsis invicta*, *Solenopsis richteri*, and the *Solenopsis* hybrid. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 140-147.

54. DIFFIE, S., M. BASS, and B. SPARKS. 1992. Control of the Imported Fire Ant in Turf. Proc. of the 1992 Imported Fire Ant Conference (C. S. Lofgren, ed.). Dept. of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico. pp. 42-49.

55. DIFFIE, S., G. DAVIS and M. H. BASS. 1994. The Variability of RIFA Colony Densities in Similar Habitats: Contributing Factors. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 9-24.

56. DIFFIE, S., J. M. RUTER and M. BASS. 1995. The impact of red imported fire ants on ground-dwelling arthropods in a field-grown nursery in Georgia. Proc. 5th International Pest Any Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 70-77.

57. DIFFIE, S., G. VELLIDIS and M. SMITH. 1991. Ground Penetrating Radar: A Look into Fire Ant Mounds Underground and their Possible Effects on Groundwater. Proc. of the 1991 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., The University of Georgia, Athens, Georgia. pp. 106-110.

58. DREES, B. M. 1988. Evaluation of Selected Alternative Red Imported Fire Ant Mound Treatments: The Aardvark, the Antser, Earthfire, and Hot Water. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 165-171.

59. DREES, B. M. 1990. Evaluation of Program Approaches to Imported Fire Ant Management. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University. College Station, Texas. pp. 62-71.

60. DREES, B. M. 1992. Impact of Red Imported Fire Ant Predation on Low-nesting Colonial Waterbirds on the Rollover Pass Islands, Texas. Proc. of the 1992 Imported Fire Ant Conference (C. S. Lofgren, ed.). Dept. of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico. pp. 25
31.

61. DREES, B. M. and C. L. BARR. 1994. The Effect of Controlled Burning, Grazing, Flooding and Insecticide Use on the Red Imported Fire Ant. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 57-68.

62. DREES, B. M., C. L. BARR and M. E. HEIMER. 1993. Skip-swath Application of Amdro and Logic Broadcast Baits for the Suppression of the Red Imported Fire Ant. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 69-72.

63. DREES, B. M., C. L. BARR and S. B. VINSON. 1991. Effects of Spot Treatments of Logic (Fenoxycarb) on Polygynous Red Imported Fire Ants: An Indication of Resource Sharing? Proc. of the 1991 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., The University of Georgia, Athens, Georgia. pp. 51-55.

64. DREES, B. M., R. CAVAZOS, L. BERGER and S. B. VINSON. 1989. Factors Affecting Sorghum and Corn Seed Feeding by the Red Imported Fire Ant (Hymenoptera: Formicidae) and the Impact of Seed Protectants. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 48-55.

65. DREES, B. M., C. L. BARR, M. E. HEIMER and R. LEPS. 1995. Reducing treatment costs for fire ant suppression in Texas cattle production systems. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 146-154.

66. DREES, B. M., C. L. BARR, M. E. HEIMER, S. B. VINSON and W. E. GRANT. 1995. Effect of red imported fire ants on wildlife (rodent) populations, Lake Conroe Dam, Montgomery County, TX, 1994: Fire ant mound monitoring and suppression program. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 117-120.

67. DYBAS, R. A. 1984. Update on the Registration Status of MK-936. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. (Abstract only) p. 54.

68. ERVIN, R. T., and W. R. TENNANT, JR. 1988. Park Users' Response to Red Imported Fire Ants in Texas. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 82-91.

69. ESGELMAN, B. D., G. H. CAMERON and E. N. N. HUYUH. 1989. Density and Dispersion of Fire Ant Mounds in a Coastal Prairie Habitat. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 14-18.

70. EVANS, D. L., K. L. JACOBSEN and D. M. MILLER. 1984. Hematologic and Immunologic Response of Holstein Calves to a Fire Ant Toxicant. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 133-137.

71. FAYE, D. D. 1995. Evaluation of TRUE STOP fire ant insecticide efficacy on red imported fire ant control (*Solenopsis invicta* Buren) control. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 180-187.

72. FERRIS, D. K., M. J. KILLION, K. P. FERRIS, W. E. GRANT and S. B. VINSON. 1995. Small mammal captures as influenced by *Solenopsis invicta* mound densities. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 111-116.

73. FOMIN, B., L. C. THOMPSON, F. N. SEMEVSKI and S. M. SEMENOV. 1995. Using historical USFWS breeding bird survey data to assess fire ant impact on birds. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 131.

74. FORSCHLER, B. T., J. S. BLACHLY and G. M. EVANS. 1995. Development of a successful control strategy against the Argentine ant based on key aspects of the pest's life history. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 28-32.

75. FOSHEE, W. and P. P. COBB. 1994. An Imported Fire Ant Control Program for a Low-Budget County Athletic Field. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 93-98.

76. FRANCKE, O. F., J. C. COKENDOLPHER and L. R. POTTS. 1984. Supercooling Studies on Four Species of Fire Ants. Proc. of the 1984 Imported Fire Ant Conference (M. E.

Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. (Abstract only) p. 72.

77. FULLER, B. W. and G. REAGAN. 1987. Fire Ant Predation in Sweet Sorghum Integrated Pest Management. Proc. of the 1987 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Louisiana State University, Baton Rouge, Louisiana. p. 58.

78. GLANCEY, B. M. 1984. Research Highlights: 1983-1984. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 138-161.

79. GLANCEY, B. M. 1986. Research Findings in Biology and Physiology. Proc. of the 1986 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Texas Dept. of Agriculture, Austin, Texas. pp. 17-28.

80. GLANCEY, B. M. 1987. Studies on the Effects of Logic on RIFA. Proc. of the 1987 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Louisiana State University. Baton Rouge, Louisiana. pp. 50-57.

81. GLANCEY, B. M. 1988. Studies of Multiple Queens and the Effect of Fenoxycarb on Virgin Alates. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 3-24.

82. GLANCEY, B. M. 1989. A Farewell to Ants -or- A Brief Review of some 1988 Research. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 79-95.

83. GREENBERG, L. and S. B. VINSON 1986. A Long-term Study of a Single-Queen/Multiple-Queen Transect. Proc. of the 1986 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Texas Dept. of Agriculture, Austin, Texas. p. 6.

84. GREENBERG, L., S. B. VINSON and S. ELLISON. 1995. Pre-adult learning in the red imported fire ant. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 191.

85. HADDAD, L. 1993. Medical Management of RIFA Stings. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 99-100.

86. HANSEN, L. D. 1995. Distribution and categorization of *Camponotus* spp. north of Mexico as nuisance or structurally damaging pests. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 18-26.

87. HEARTY, J. M. 1987. Systematics and Nest Biology of the Eucharitidae: Chalcidoid Parasites of Ants. Proc. of the 1987 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Louisiana State University, Baton Rouge, Louisiana. p. 26.

88. HELMS, T. 1993. SRIEG-34 (Imported Fire Ants): Should it be EG or SERA? Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 140.

89. HERNANDEZ, P. E. 1989. Synthesis of the Major Component of the Trail Pheromone of the Red Imported Fire Ant. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 56-57.

90. HERNANDEZ, P. E. 1991. In Search of the Holy Trail; the Recruitment Component of the IFA Trail Pheromone System. Proc. of the 1991 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., The University of Georgia, Athens, Georgia. p. 1.

91. HICKLING, R., W. WEI and L. LAMBERT. 1995. Sounds produced by imported fire ants. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 93-94.

92. HORTON, M. 1993. A Modified Plotting Table and Plot Locator for RIFA Field Studies. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. p. 97.

93. HOSMER, A. and J. S. FERGUSON. 1994. Rate of foraging by Imported Fire Ants on Logic Bait (fenoxycarb). Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University. Mobile, Alabama. pp. 109-112.

94. IRELAND, P. L. and G. N. CAMERON. 1995. Ecological impact of fire ants on the arthropod community and fitness of plants in the prairie of the upper Texas coast. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 78-82.

95. JAMES, Jr., F. K. 1989. Imported Fire Ant Venom, Then and Now. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 96-97.

96. JOHNSTON, J. S., D. SEBESTA, and S.B. VINSON. 1992. Diploid Sperm and Triploid Polygene Fire Ants in Walton Co., Georgia. Proc. of the 1992 Imported Fire Ant Conference (C. S. Lofgren, ed.). Dept. of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico. p. 32.

97. JONES, D., L. THOMPSON and K. DAVIS. 1995. Can a one-two punch of Logic-Orthene be used to eradicate fine ants? Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 161-164.

98. JOUVENAZ, D. P. 1989. Endoparasitic Fungi of Fire Ant Solenopsis spp. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 19-20.

99. JOUVENAZ, D. P. and R. S. PATTERSON. 1991. Nematode Parasites of Fire Ants from South America. Proc. of the 1991 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., The University of Georgia, Athens, Georgia. pp. 73-81.

100. JUSINO-ATRESINO, R., S. PHILLIPS and M. WILLING. 1990. Modification of Temporal Foraging Activities of Texas Native Ants in Response to the Red Imported Fire Ant. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. p. 2.

101. KARR, G. 1994. IFA in Alabama - Update. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 1-2.

102. KILLION, M. J., W. E. GRANT, and S. B. VINSON. 1990. Influence of Red Imported Fire Ants on Small Mammal Habitat Utilization. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. pp. 43-44.

103. KILLION, M. J., S. B. VINSON and W. E. GRANT. 1991. Small Mammal Community Response to Red Imported Fire Ant Removal. Proc. of the 1991 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., The University of Georgia, Athens, Georgia. pp. 2-7.

104. KISSAM, J. B. and P. M. HORTON. 1989. Long Term Suppressive Effects of Commercial Bait Products on Red Imported Fire Ant, *Solenopsis invicta*, Infecting Cattle Pastures. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 129-131.

105. LANDRY, C. E., S. A. PHILLIPS, JR. and H. G. THORVILSON. 1995. Ice-nucleating active bacteria as a winter management tactic for the red imported fire ant. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 102-104.

106. LAPOINTE, S. L. and M. S. SERRANO. 1995. Ecology and control of the attine ant *Acromyrmex landolti* in neotropical savanna. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 45-49.

107. LIN, T., R. BERGER and P. JOSEPH. 1994. Environmental Monitoring for the Imported Fire Ant Regulatory Program in APHIS, US. Dept. of Agriculture. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 76-80.

108. LOCKLEY, T. C. 1990. Systematic Survey of the Three Coastal Counties of Mississippi for Incidence of Polygynous Colonies of the Red Imported Fire Ant, *Solenopsis invicta* Buren. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. pp. 12-18.

109. LOCKLEY, T. C. 1993. The Effects of Red Imported Fire Ants on a Nesting Population of Least Terns: An Endangered Species. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 123-128.

110. LOCKLEY, T. C. 1995. Food preferences of *Solenopsis invicta* among seeds of wildflowers native to the Southeastern United States. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 83.

111. LOCKLEY, T. C. and A. J. LAICHE. 1989. Relative Phytoxicity of Dursban 2.5G (chlorpyrifos) in a Standard Potting Media to Selected Foliage and Woody Landscape Plants. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 98-107.

112. LOFGREN, C. S. 1987. A Quarter Century of Imported Fire Ant Research Meetings. Proc. of the 1987 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Louisiana State University, Baton Rouge, Louisiana. pp. 1-6.

113. LOFGREN, C. S. 1988. IR-4 Residue Studies for the Registration of Logic for Control of Imported Fire Ants in Potatoes and Soybeans. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 47-49.

114. LOFGREN, C. S. and DAVID F. WILLIAMS. 1984. Reinfestation Rates of Imported Fire Ants Following Toxic Bait Treatments. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 112-119.

115. LONG, W. H., L. D. NELSON, P. J. TEMPLET and C. P. VIATOR. 1987. Effects of Soil Texture on the Abundance of Red Imported Fire Ants and Sugarcane Borers. Proc. of the 1987 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Louisiana State University, Baton Rouge, Louisiana. pp. 29-38.

116. LOVELACE, S. R. and J. B. KISSAM. 1991. Observations of the Red Imported Fire Ant, *Solenopsis invicta* Buren in Turkey Grow Out Houses and Preliminary Control investigations, Jefferson, SC 1990. Proc. of the 1991 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., The University of Georgia, Athens, Georgia. p. 111.

117. LUTZ, R. L. and S. DEMARAIS. 1990. Impact of Fire Ants on Wildlife: Research Needs. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. pp. 39-42.

118. LUTZ, R. S., C. ALLEN, and S. DEMARAIS. 1992. Preliminary Results of the Impact of the Red Imported Fire Ant Reductions on Wildlife Populations. Proc. of the 1992 Imported Fire Ant Conference (C. S. Lofgren, ed.). Dept. of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico. pp. 1-6.

119. LUTZ, R. S., C. ALLEN and S. DEMARAIS. 1993. The Response of Northern Bobwhite to Red Imported Fire Ant Reductions. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 117.

120. LUTZ, R. S., W. M. GIULIANO, C. R. ALLEN and S. DEMARAIS. 1995. The impact of red imported fire ants on bobwhite quail chicks. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. p. 110.

121. MACKAY, W. 1990. Control of the Imported Fire Ant in Electrical Equipment. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. pp. 51-54.

122. MANNING, R. and J. BRUCKNER. 1988. Elimination of a Fluorinated Sulfonamide Insecticide in the Rat. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 129-139.

123. MARTIN, J., S. B. VINSON, W. GRANT and B. M. DREES. 1995. Effects of the imported fire ant on wildlife, Lake Conroe Dam, Montgomery County, TX: Preliminary fire ant activity on managed plots over time. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 121-122.

124. McANALLY, L. R. 1990. Evaluation of Drench Treatments for Certification of Containerized Nursery Stock. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. pp. 72-79.

125. McANALLY, L. R. 1993. Relative Phytotoxicity of Tefluthrin (Force 1.5G) to Selected Ornamentals. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 58-66.

126. McANALLY, L. R. 1994. Residual Activity of Drench Treatment Candidate (1991-1993). Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 115-122.

127. McANALLY, L. R., H. COLLINS, A-M. CALLCOTT and A. LADNER. 1995. Control of imported fire ants around poultry production houses, 1994. Proc. 5th International Pest Ant

Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 132-137.

128. McILVEEN, JR., G., S. B. VINSON and F. W. PLAPP, JR. 1995. Interaction of *Solenopsis invicta* Buren and *Pheidole dentata* Mayr on parasitized and non-parasitized cockroach oothecae. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 36-44.

129. McINNES, D. 1989. Mating Flights and Reproductive Investment: A comparison of *Solenopsis invicta* and *S. geminata* in north Florida. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station. Gulfport, Mississippi. pp. 8-13.

130. MERCHANT, M. E. 1995. Consumer evaluation of the two-step method for fire ant control. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 157-160.

131. MILES, J. 1994. Who's Asking About Fire Ants and What Do They Want to Know? Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University. Mobile, Alabama. pp. 135-136.

132. MILLER, K. L., G. CROSSLAND and L. SCHUTZMAN. 1994. A City Fights Back Against Fire Ants - The Amdro Aerial Attack. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 113-114.

133. MILLER, K. L. and K. IFTNER. 1993. Broadcast Spreader Equipment for Amdro Applications. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 93-96.

134. MILLER, K., L. SCHUTZMEN, S. FAIRCHILD, R. ECKSTEIN and N. ADAMS. 1995. A lawn care operator's approach to neighborhood fire ant control. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 188.

135. MILLER, R. W. 1989. Field Trial Results of *Steinernema feltiae* Applications for Control of Red Imported Fire Ant in 1988. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 34-47.

136. MILLER, R. W., B. M. DREES, S. B. VINSON and R. GEORGIS. 1988. Response of Imported Fire Ant to Applications of *Neoaplectana carpocapsae*. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 107-110.

137. MINTZER, A. C. 1995. Ecological determinants of palo-verde tree and creosote bush targeting by the leafcutting ant *Atta mexicana* in the Sonaran desert of Arizona. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 171.

138. MISPAGEL, M. E. 1986. The Effect of Abamectin on RIFA Alate Fertility. Proc. of the 1986 Imported Fire Ant Conference (M.E. Mispagel, Ed.). The Texas Dept. of Agriculture, Austin, Texas. pp. 51-55.

139. MISPAGEL, M. E. 1987. The Environmental Toxicology Program at the University of Georgia. Proc. of the 1987 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Louisiana State University, Baton Rouge, Louisiana. p. 63.

140. MOUNT, G. A., D. G. HAILE and D. F. WILLIAMS. 1988. Simulation of the Population Dynamics of the Imported Fire Ant, *Solenopsis invicta*. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 66-68.

141. MULDER, R. 1988. A Fire Ant Management Plan for Texas. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 92.

142. MULDER, R. 1989. Texas Dept. of Agriculture 1989 Imported Fire Ant Program. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 115-122.

143. MUNROE, P. D. and H. G. THORVILSON. 1987. Comparison of Desiccation Resistance of Three Fire Ant Species for Texas. Proc. of the 1987 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Louisiana State University. Baton Rouge, Louisiana. pp. 27-28.

144. OBIN, M. and R. K. VANDER MEER. 1984. Airborne Venom Dispersal in *Solenopsis*: Functional Correlates of Insecticidal and Antibiotic Venom Properties. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 73-86.

145. OI, D. H. and D. F. WILLIAMS. 1994. Susceptibility of Monogyne and Polygyne Imported Fire Ants to Indoor Ant Baits. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 83-90.

146. OI, D. H. and D. F. WILLIAMS. 1995. Effect of alternative bait formulations on imported fire ants and non-target ant populations. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 171.

147. OI, D. H., K. M. VAIL, J. H. KLOTZ and D. F. WILLIAMS. 1995. Responses of *Tapinoma melanocephalum*, Argentine ants, and Pharaoh ants to boric acid bait. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. p. 27.

148. OWENS, V. J. 1993. Health Effects of the Red Imported Fire Ant. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 101-108.

149. PATTERSON, R. S. 1989. Efficiency of Biocontrol Organism *Thelohania solenopsae* (Microspora: Microsporida) to Suppress Fire Ant Population in Argentina. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 23-33.

150. PATTERSON, R. S. 1990. Status of Fire Ant Research, USDA. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. pp. 46-50.

151. PATTERSON, R. S. 1991. The Imported Fire Ant: A Major Urban Pest. Proc. of the 1991 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., The University of Georgia, Athens, Georgia. pp. 89-93.

152. PAUSTENBACH, D. 1984. An Environmental Risk Assessment of Pro-Drone; Insect Growth Regulator for Controlling the Red Imported Fire Ant (*Solenopsis invicta*). Proc. of the 1984

Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 55-65.

153. PEDERSON, E. K., W. E. GRANT, S. B. VINSON, M. L. LONGNECKER and B. M. DREES. 1995. Effects of the imported fire ant on wildlife, Lake Conroe Dam, Montgomery County, TX: Preliminary analysis of small mammal response. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 123-130.

154. PETTY, D. B., K. G. LEIN and J. L. TURNER. 1995. Fire ant community ABAITment program. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 172-178.

155. PHILLIPS, JR., S. 1986. An Insect Growth Regulator (Pro-Drone) for Effective Management of the Red Imported Fire Ant. Proc. of the 1986 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Texas Dept. of Agriculture, Austin, Texas. p. 88.

156. PHILLIPS, JR., S. A. and G. R. CAMILO. 1987. Ant assemblages along the Westernmost Range of *Solenopsis invicta*. Proc. of the 1987 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Louisiana State University. Baton Rouge, Louisiana. pp. 7-17.

157. PHILLIPS, JR., S. and J. COKENDOLPHER. 1990. Critical Thermal Limits and Locomotor Activity of the Red Imported Fire Ant. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. p. 1.

158. PHILLIPS, JR., S. A., D. M. CLABORN, and D. WESTER. 1984. Foraging Strategies of Native Ants in Fire Ant Infested Areas of Central Texas. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 179-196.

159. PORTER, S. D. 1988. The Effects of Boric Acid Bait on Laboratory Fire Ant Colonies. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 79-81.

160. PORTER, S. D. 1995. Potential use of *Pseudacteon* phorid flies as fire ant biocontrol agents. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. p. 95.

161. PORTER, S. D., D. F. WILLIAMS and R. S. PATTERSON. 1993. Factors Affecting the Relative Densities of Fire Ants in North and South America. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. p. 68.

162. QUERY, O. G. 1984. Accudose Aerosol Injection Methods of Fire Ant Control with Pyrethrins or Dursban. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 205-212.

163. REAGAN, G. 1988. Current Fire Ant Research Activities at LSU. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. p. 106.

164. REAGAN, G. and L. M. RODRIQUEZ. 1993. The Imported Fire Ant in Louisiana Sugarcane: Some Comments on Stability and Enhancement of Predation. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. p. 21.

165. REAVES, H. L. 1988. Introductory Remarks. Proc. of the 1988 Imported Fire Ant

Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia. Athens, Georgia. pp. 1-2.

166. SANCHEZ-PENA, S. R. and H. G. THORVILSON. 1991. The Entomopatholenic Fungus *Beauveria bassiana* for Fire Ant Management in Nursery Stock. Proc. of the 1991 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., The University of Georgia. Athens, Georgia. pp. 94-105.

167. SARAPUU, E. 1990. In situ Electrical Extermination of Ants. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. pp. 109-110.

168. SCHUMAN, S. 1993. Epidemiology of IFA Morbidity Mortality. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 109-111.

169. SEMENOV, S. M., L. C. THOMPSON and D. B. JONES. 1995. Have we 'maxed-out' on fire ant control with baits? Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 170.

170. SHANKLAND, D. L. 1984. Bill Buren: Scholar With a Mission. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 4-5.

171. SHEPPARD, D. C. and S. DIFFIE. 1988. Susceptibility of "Hybrid" Fire Ants and Their Parent Species to Insecticide Residues. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia. Athens, Georgia. pp. 99-101.

172. SHEPPARD, D. C. and C. A. GATES. 1984. A Citrus Based Solvent as a RIFA Mound Drench Material. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 106-111.

173. SHEPPARD, D. C. and M. J. TOWNSEND. 1989. Amount of Bait Taken by Red Imported Fire Ants: Effects of Alternate Food, Addition of Toxicant and Season. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 108-114.

174. SHOWLER, A. T., R. M. KNAUS, and G. REAGAN. 1987. Neutron Activation Analysis for Determining the Territorial Areas of Discrete Imported Fire Ant Colonies. Proc. of the 1987 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Louisiana State University, Baton Rouge, Louisiana. p. 24.

175. SIEBENEICHER, S., S. B. VINSON and C. M. KENERLEY. 1990. Routes of Infection of *Beauveria* in the Red Imported Fire Ant. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. p. 45.

176. SLOWIK, T. J. and H. G. THORVILSON. 1995. Localization of biogenic ferromagnetic material in the red imported fire ant (RIFA), *Solenopsis invicta* Buren. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 92.

177. SLOWIK, T. J., H. G. THORVILSON and B. L. GREEN. 1995. Response of the red imported fire ant (RIFA), *Solenopsis invicta* Buren, to current and conductive material of active electrical equipment. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. p. 91.

178. SORENSEN, A. and M. TROSTLE. 1986. Fire Ant Project: Answers To Your Questions About Imported Fire Ants. Proc. of the 1986 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Texas Dept. of Agriculture, Austin, Texas. pp. 44-50.

179. SPARKS, B. 1992. Red Imported Fire Ants in Poultry Operations. Proc. of the 1992 Imported Fire Ant Conference (C. S. Lofgren, ed.). Dept. of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico. pp. 79-80.

180. STAMPS, T. 1987. Colony Merging in the Imported Fire Ant. Proc. of the 1987 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Louisiana State University, Baton Rouge, Louisiana. p. 23.

181. STEIN, M. B. and H. G. THORVILSON. 1986. Seasonal Changes in Bait Preference and Recruitment of Red Imported Fire Ants. Proc. of the 1986 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Texas Dept. of Agriculture, Austin, Texas. p. 7.

182. STIMAC, J. 1984. Studies on the Ecology of *Solenopsis* in Mato Grosso, Brazil. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. p. 11.

183. TABER, S. and J. COKENDOLPHER. 1986. Supercooling of Red Imported Fire Ants from Lubbock, Texas. Proc. of the 1986 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Texas Dept. of Agriculture, Austin, Texas. pp. 8-15.

184. TAYLOR, T. D. 1994. Red Imported Fire Ant Control with Award: Fertilizer Blends -- a Progress Report. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 123-134.

185. TAYLOR, T. D., D. HOUMES, J. CLARY and J. HARPER. 1993. Moundville Alabama: A Community RIFA Control Project. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 82-92.

186. TEDDERS, L. 1989. Impact of Imported Fire Ants on Pecans in Georgia. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station. Gulfport, Mississippi. pp. 64-78.

187. TENNANT DE ALONSO, L.E. and R. K. VANDER MEER 1995. Source of alate alarm pheromones in *Solenopsis invicta*. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 33-35.

188. THOMPSON, L. C., and D. JONES. 1994. Fire Ant Impacts in Arkansas - Results of A Survey. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 25-34.

189. THOMPSON, L. C., M. KORZUKHIN, R. ADAMS AND D. JONES. 1993. Fire Ant Research in Arkansas. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. p. 1.

190. THOMPSON, L. C., D. B. JONES, F. N. SEMEVSKI, and S. M. SEMENOV. 1995. Fire ant economic impact: extending Arkansas' survey results over the South. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 155-156.

191. THORVILSON, H. G. and S. A. PHILLIPS. 1986. Straw Itch Mites as a Bicontrol Agent of Red Imported Fire Ants. Proc. of the 1986 Imported Fire Ant Conference (M. E. Mispagel,

ed.). The Texas Dept. of Agriculture, Austin, Texas. pp. 70-75.

192. THORVILSON, H. G. and S. A. PHILLIPS, JR. 1988. Field Trials of LOGIC for Red Imported Fire Ant Management. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 148-154

193. THORVILSON, H. G. and S. A. PHILLIPS, JR. 1993. Fire Ant and Native Ant Population Responses After Amdro Applications. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 112-116.

194. THORVILSON, H. G. and H. G. WHITE. 1994. Fire Ant Mortality Caused by an Alginate-Formulated Fungus. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 55-56.

195. THORVILSON, H. G., S. A. PHILLIPS, M. TROSTLE and A. FIELD. 1992. Response of Native Ants to Red Imported Fire Ant Population Suppression. Proc. of the 1992 Imported Fire Ant Conference (C. S. Lofgren, ed.). Dept. of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico. pp. 7-17.

196. TONIOLO, S. R. 1988. Comparison of Electrophoretic Patterns in Individual Workers of *Solenopsis invicta* Buren, *S. richteri* Forel and Their Hybrid. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 44-46.

197. TRAGER, J. 1984. Fire Ant Taxonomy-- Whither Now? Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. (Abstract only) p. 6.

198. TROSTLE, M. R. 1984. 1983 Texas Imported Fire Ant Pro-Drone Aerial Application Program. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. p. 87.

199. TROSTLE, M. R. 1984. Questions and Answers on Pro Drone Application Program. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 88-91.

200. TROSTLE, M. R. 1987. 1987 Texas Dept. of Agriculture Imported Fire Ant Program. Proc. of the 1987 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Louisiana State University, Baton Rouge, Louisiana. pp. 59-62.

201. TROSTLE, M. R. 1988. Baits for Fire Ant Management on Texas Sod Farms. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 69-74.

202. TROSTLE, M. R. 1989. Ground Application of Bait Toxicants to Texas Sod Farms. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 123-128.

203. VANDER MEER, R. K. 1984. Recent Discoveries in Fire Ant Chemistry, Physiology, and Behavior. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 12-24.

204. VANDER MEER, R. K. 1986. Recent Chemical Studies on the Imported Fire Ants, *Solenopsis invicta* and *S. richteri*. Proc. of the 1986 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Texas Dept. of Agriculture, Austin, Texas. pp. 1-2.

205. VANDER MEER, R. K. 1987. Recent Chemical Studies on Fire Ants. Proc. of the 1987 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Louisiana State University, Baton Rouge, Louisiana. p. 49.

206. VANDER MEER, R. K. 1988. Fire Ant Semiochemicals: 1987-1988. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia. Athens, Georgia. pp. 25-36.

207. VANDER MEER, R. K. 1989. Fire Ant Chemical Research: 1988-1989. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station. Gulfport, Mississippi. pp. 58-63.

208. VANDER MEER, R. K. 1992. Individual and Colony Level Fire Ant Variation in Responsiveness. Proc. of the 1992 Imported Fire Ant Conference (C. S. Lofgren, ed.). Dept. of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico. pp. 77-78.

209. VANDER MEER, R. K. 1994. What's Hot and What's Not in Fire Ant Chemical Ecology. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 69-70.

210. VANDER MEER, R. K. and R. S. PATTERSON. 1991. Fire Ant Species-Specific Baits and Repellents. Proc. of the 1991 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., The University of Georgia. Athens, Georgia. pp. 56-58.

211. VANDER MEER, R. K. and J. A. SEAWRIGHT. 1993. Fire Ant Orientation, Repellents, and Bait Enhancement with Pheromones. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. p. 67.

212. VANDER MEER, R. K. and J. A. SEAWRIGHT. 1994. Diatomaeous Earth, Repellents, Pyrethrins and Fire Ant Control. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 91-92.

213. VANDER MEER, R. K. and J. A. SEAWRIGHT. 1995. Development of pheromone enhanced baits and other technology transfer activities. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 179.

214. VANDER MEER, R. K., G. L. HEHMAN, A. J. COCKBURN and J. A. SEAWRIGHT. 1995. Research on the molecular biology of fire ants. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. p. 90.

215. VANDER MEER, R. K., C. S. LOFGREN, and DAVID F. WILLIAMS. 1984. Fluorinated Sulfonamides: A New Class of Delayed Action Insecticides. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 27-39.

216. VANDER MEER, R. K., W. A. BANKS, C. S. LOFGREN and J. A. SEAWRIGHT. 1994. Fire Ant Repellents: discovery to Technology Transfer. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 81-82.

217. VARGO, E. L. 1995. Inhibition of reproduction by queen pheromones in fire ants. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. p. 84.

218. VINSON, S. B. 1984. Current Research Efforts on The Imported Fire Ant at Texas A&M. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida

Institute of Food and Agricultural Science, Gainesville, FL. (Abstract only) p. 25.

219. VINSON, S. B. 1988. Current Fire Ant Research Activities at Texas A&M. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 102-105.

220. VINSON, S. B. 1990. Impact of Fire Ants on a Small Arthropod Community. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. pp. 35-38.

221. VINSON, S. B. 1992. Challenges to a Determination of the Economic Impact of the Imported Fire Ants. Proc. of the 1992 Imported Fire Ant Conference (C. S. Lofgren, ed.). Dept. of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico. pp. 33-41.

222. VINSON, S. B. 1994. Impact of the Imported Fire Ant on Decomposer Communities is Dependent on the Resource Size. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 47-52.

223. VINSON, S. B. and T. STAMPS. 1990. Queen Acceptance in Orphaned Colonies of Polygyne and Monogyne Workers. Proc. of the 1990 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Texas A&M University, College Station, Texas. pp. 30-34.

224. VINSON, S. B., D. FERRIS, R. SOKLER, K. FERRIS, C. READY and W. GRANT. 1993. The Impact of the Red Imported Fire Ant on Select Components of the Texas Coastal Prairie. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 129-139.

225. WALLER, D. A. 1986. *Solenopsis invicta* Predation on Subterranean Termites. Proc. of the 1986 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Texas Dept. of Agriculture, Austin, Texas. p.3-5.

226. WALLER, D. A. 1992. Fire Ant Infestation in the Tidewater Area of Virginia. Proc. of the 1992 Imported Fire Ant Conference (C. S. Lofgren, ed.). Dept. of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico. pp. 18-24.

227. WALLER, D. A. 1993. Current Status of Fire Ant Infestations in Virginia. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 2-5.

228. WALLER, D. A. 1995. Recruitment patterns in foraging leafcutting ants (Formicidae: Attini): Implications for baiting strategies. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 10-17.

229. WHITE, H. E., H. G. THORVILSON, S. A. PHILLIPS, JR. and J. C. ZAK. 1995. Alginate formulations of *Beauveria bassiana*. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 105-106.

230. WILLIAMS, D. F. 1984. Current Research with Toxic Baits. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 66-71.

231. WILLIAMS, D. F. 1986. Effects of Two Fire Ant Bait Toxicants on Natural Populations of Non-target Ants. Proc. of the 1986 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Texas Dept. of Agriculture, Austin, Texas. pp. 83-87.

232. WILLIAMS, D. F. 1987. Some Studies of Oviposition Rates of Imported Fire Ant Queens. Proc. of the 1987 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., Louisiana State University, Baton Rouge, Louisiana. pp. 18-22.

233. WILLIAMS, D. F. 1988. Recent Studies on Growth and Development of Fire Ant Colonies. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 63-65.

234. WILLIAMS, D. F. 1989. Influence of Temperature on Colony Growth of the Imported Fire Ant, *Solenopsis invicta*. Proc. of the 1989 Imported Fire Ant Conference (M. E. Mispagel, ed.). U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service, Science and Technology, Imported Fire Ant Station, Gulfport, Mississippi. pp. 21-22.

235. WILLIAMS, D. F. 1991. Population Densities of the Ant Fauna Including *Solenopsis invicta* in Pastures in Brazil. Proc. of the 1991 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., The University of Georgia, Athens, Georgia. pp. 8-16.

236. WILLIAMS, D. F. and D. H. OI. 1994. Comparison of Fly Pupa and Corn Grit Formulated Fire Ant Baits. Proc. of 1994 Imported Fire Ant Conference, Dept. of Ent., Auburn University, Mobile, Alabama. pp. 71-75.

237. WILLIAMS, D. F., H. COLLINS, D. H. OI, T. LOCKLEY and A-M. CALLCOTT. 1995. Studies of an imported fire ant population in Eastern Tennessee. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. pp. 62-69.

238. WILSON, D. and J. BOWEN. 1986. Preliminary Electrophysiological Evaluations of the Effects of Avermectin and GX-071 on the Imported Fire Ant, *Solenopsis invicta* Buren. Proc. of the 1986 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Texas Dept. of Agriculture, Austin, Texas. p. 56.

239. WOJCIK, D. P. 1986. Status of the Search for Natural Control Agents in South America. Proc. of the 1986 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Texas Dept. of Agriculture, Austin, Texas. pp. 29-37.

240. WOJCIK, D. P. 1988. Survey for Biocontrol Agents of Fire Ants in Brazil, a Final Report. Proc. of the 1988 Imported Fire Ant Conference (M. E. Mispagel, ed.). The Georgia Center for Continuing Education, The University of Georgia, Athens, Georgia. pp. 50-62.

241. WOJCIK, D. P. 1992. Update on Mating Flight Studies, 1991-1992. Proc. of the 1992 Imported Fire Ant Conference (C. S. Lofgren, ed.). Dept. of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico. pp. 120-123.

242. WOJCIK, D. P. 1992. The effects on Non-target ants of Pre- and Post-mating Flight Toxicant Applications for Fire Ant Control. Proc. of the 1992 Imported Fire Ant Conference (C. S. Lofgren, ed.). Dept. of Agriculture, Commonwealth of Puerto Rico, San Juan, Puerto Rico. pp. 124-136.

243. WOJCIK, D. P. 1993. The Gainesville Transect: Twenty-one Years of Population Increases. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 6-20.

244. WOJCIK, D. P., and R. S. PATTERSON. 1991. Studies of Bait Toxicants on Red Imported Fire Ants and Non-Target Ants in South Florida, 1989-1991. Proc. of the 1991 Imported Fire Ant Conference (M. E. Mispagel, ed.). Dept. of Ent., The University of Georgia, Athens, Georgia. p. 59.

245. WOJCIK, D. P., and R. S. PATTERSON. 1993. Seasonality of RIFA Mating Flights. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 22-34.

246. WOJCIK, D. P., and J. SMALLWOOD. 1993. Red Imported Fire Ant Predation on Kestrels. Proc. of the 1993 Imported Fire Ant Research Conference, Ent. Dept., Clemson University, Charleston, South Carolina. pp. 120-122.

247. WOJCIK, D. P., R. J. BURGESS, and C. M. BLANTON. 1984. Diurnal and Seasonal Differences in RIFA Roadside Abundance. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 120-130.

248. WOJCIK, D. P., R. J. BURGESS, and C. M. BLANTON. 1984. A Technique for Marking Fire Ants. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. pp. 131-132.

249. WOOD, L. 1984. Imported Fire Ant Resurgence Following Chemical Treatment of Pastures. Proc. of the 1984 Imported Fire Ant Conference (M. E. Mispagel, ed.). University of Florida Institute of Food and Agricultural Science, Gainesville, FL. p. 10.

250. ZAKHAROV, A. A. and L. C. THOMPSON. 1995. Effects of Logic and Amdro baits on non-target ants. Proc. 5th International Pest Ant Symposia and the 1995 Imported Fire Ant Conference (S. B. Vinson and B. M. Drees, eds.). San Antonio, Texas. p. 190.